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Iron and Steel Manufacturing

Point Source Category

Vol. I

General

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PRETREATMENT STANDARDS

for the

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PREFACE

The United States Environmental Protection Agency is proposing effluent limitations and standards for the steel industry. The proposed regulation contains effluent limitations for best practicable control technology currently available (BPT), best conventional pollutant control technology (BCT), and best available technology economically achievable (BAT), as well as pretreatment standards for new and existing sources (PSNS and PSES), and, new source performance standards (NSPS), pursuant to Sections 301, 304, 306, 307 and 501 of the Clean Water Act.

This Development Document highlights the technical aspects of EPA's study of the steel industry. Volume I of the Development Document discusses general issues pertaining to the industry, while the remaining volumes focus on particular subcategories or processes of the industry.

The Agency's economic analysis of the proposed regulation is set forth in a separate document entitled Economic Analysis of Proposed Effluent Guidelines - Integrated Iron and Steel Industry. That document is available from the Office of Planning and Evaluation, PM-220, USEPA, Washington, D.C., 20460.

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SECTION I

CONCLUSIONS AND RECOMMENDATIONS

1. Total process water usage in the steel industry is about 6,300,000,000 (6300 MGD) gallons per day. These raw process waters contain about 47,000 tons/year of toxic organic pollutants, 140,000 tons/year of toxic inorganic pollutants, and 14,600,000 tons/year of conventional and nonconventional pollutants. These highly contaminated process wastewaters are treatable by currently available, practicable and economically achievable control and treatment technologies.

2. The proposed regulation contains limitations for the different subcategories or segments of the industry. The subcategorization is based primarily on manufacturing processes. The Agency has adopted a revised subcategorization of the industry to more accurately reflect production operations in the industry and to simplify the use of the regulation. This subcategorization does not affect the substantive requirements of the proposed regulation. The 12 subcategories of the steel industry covered by the proposed regulation are:

A. Cokemaking

   1. By-Product
   2. Beehive

B. Sintering

C. Ironmaking

D. Steelmaking

   1. Basic Oxygen Furnace

      a. Semi-wet
      b. Wet-Suppressed Combustion
      c. Wet-Open Combustion

   2. Open Hearth Furnace

      a. Semi-Wet
      b. Wet

   3. Electric Arc Furnace

      a. Semi-Wet
      b. Wet

E. Vacuum Degassing

F. Continuous Casting

G. Hot Forming

1. Primary
    a. Carbon and Specialty without Scarfers
    b. Carbon and Specialty with Scarfers

2. Section
    a. Carbon
    b. Specialty

3. Flat
    a. Hot Strip and Sheet
    b. Carbon Plate
    c. Specialty Plate

4. Hot Working Pipe & Tube

H. Scale Removal

1. Kolene
2. Hydride

I. Acid Pickling

1. Sulfuric Acid
    a. Acid Recovery-Batch
    b. Acid Recovery-Continuous
    c. Neutralization-Batch
    d. Neutralization-Continuous

2. Hydrochloric Acid
    a. Acid Regeneration-Continuous
    b. Neutralization-Batch
    c. Neutralization-Continuous

3. Combination Acid
    a. Neutralization-Batch
    b. Neutralization-Continuous

J. Cold Forming

1. Cold Rolling
    a. Recirculation
    b. Combination
    c. Direct Application

2. Cold Worked Pipe and Tube

    a. Water
    b. Oil solutions

K. Alkaline Cleaning

L. Hot Coating

1. Galvanizing
    a. Strip, Sheet and Miscellaneous Products without scrubbers
    b. Strip, Sheet and Miscellaneous Products with scrubbers
    c. Wire Products and Fasteners without scrubbers
    d. Wire Products and Fasteners with scrubbers

2. Terne
    a. Strip, Sheet, without scrubbers
    b. Strip, Sheet, with scrubbers

3. Other Metals
    a. Strip, Sheet and Miscellaneous Products without scrubbers
    b. Strip, Sheet and Miscellaneous Products with scrubbers
    c. Wire Products and Fasteners without scrubbers
    d. Wire Products and Fasteners with scrubbers

3. For the most part, the BPT effluent limitations promulgated in 1974 and 1976 are practicable and achievable by all steel facilities. In fact, the expanded data base for the industry developed as part of this study shows that prior BPT effluent limitations in many subcategories are less stringent than could have been justified. Nonetheless, in most cases the proposed BPT limitations contained herein are the same as the BPT limitations previously promulgated. In a few instances, the proposed BPT effluent limitations have been relaxed from previously promulgated BPT levels where the previous limitations could not be supported. Table I-1 presents the originally promulgated BPT effluent limitations and the revised BPT limitations, where applicable.

4. EPA estimates that based upon production and treatment facilities in place as of January 1, 1978, the industry will incur the following costs in complying with the proposed regulation.

Costs (Millions of July 1, 1978 Dollars)

	Capital Costs			Total
	Total	In-place	Required	Annual
BPT	2277	1526	751	303
BAT	719	125	594	150
TOTAL	2996	1651	1345	453

NOTE: Costs for BCT are included in those for BAT; and, costs for PSES are included in those for BPT and BAT.

Table I-2 presents a summary of these costs by subcategory. The Agency believes the environmental benefits associated with compliance with the proposed limitations and standards outweigh the costs of compliance.

The relatively high capital cost required for BPT reflects the limited compliance of the industry, in general, with BPT as of January 1, 1978 (the baseline date for this study). BPT was to have been achieved by July 1, 1977.

It should be noted that the industry profile used for this study and included throughout the development document includes many facilities permanently shutdown during the past few years. Hence, the actual cost to the industry as it stands today will be lower than shown above for BPT and BAT. For example, a substantial portion of the required BPT costs is associated with plants permanently shut down in the Mahoning Valley of Ohio. EPA estimates that as of June 30, 1980, the remaining "required BPT" costs are less than 500 million dollars. Of the 719 million dollars' total capital cost for BAT shown above, over 200 million dollars have been spent; have been committed to be spent prior to July 1, 1984 through consent agreements and permits resulting from state and federal enforcement actions; or, will not be spent because of plant shutdowns.

The industry production capacity profile used in this study differs slightly from that used in the preparation of Economic Analysis of Proposed Effluent Guidelines - Integrated Iron and Steel Industry which reviews in detail the potential economic impact of this proposed regulation. The capacity profile used in that analysis is based upon information obtained from AISI and includes predictions of future retirements, modernization, and reworks not included in this study.

5. EPA estimates that compliance with the proposed BPT and BAT effluent limitations will result in significant removals of toxic, conventional and other pollutants. A summary of the removal occurring from the proposed BPT limitations to the proposed BAT limitations is shown below.

	Process Flow (MGD)	Effluent Discharges (Tons/Yr)		
		Toxic Organics	Toxic Inorganics	Other Pollutants
BPT	2948	2153	2744	140,490
BAT	302	247	222	10,299
% Reduction	90	89	92	93

Table I-3 presents a summary of these discharges by subcategory.

6. In developing the proposed BAT effluent limitations, EPA considered between two and five alternative treatment systems for each subcategory. The effluent limitations for the selected BAT Alternatives are presented in Table I-4.

7. The Agency developed best conventional technology (BCT) alternative treatment systems compatible with the respective BAT alternative treatment systems for each subcategory. EPA evaluated the cost and the reasonableness of controlling

conventional pollutants (i.e. total suspended solids and oil and grease) and found that in many subcategories conventional pollutant removal costs based on BCT treatment systems are less than the removal costs experienced by publicly owned treatment works (POTWs). In those cases, the Agency concluded that the costs are reasonable and has established BCT limitations more stringent than BPT. In other subcategories where conventional pollutant removal costs exceeded the costs experienced by POTWs ($1.34/lb 1978 dollars), the proposed limitations for conventional pollutants are the same as the proposed BPT limitations. The proposed BCT effluent limitations are presented on Table I-5. Table I-6 presents the model flows and concentrations used to develop the proposed BAT and BCT limitations.

8. In developing proposed NSPS, EPA evaluated between two and five alternative treatment systems for each subcategory of the industry. In most cases, proposed NSPS are equal to proposed BAT effluent limitations.

9. In developing proposed pretreatment standards for existing sources (PSES) and new sources (PSNS), EPA evaluated between two and four alternative treatment systems for each subcategory of the industry. Proposed PSES and PSNS limit the discharge of pollutants that interfere with, pass through, or are otherwise incompatible with the operation of POTWs. In most cases, the proposed standards for toxic pollutants are the same as the limitations proposed for BAT. Table I-7 presents a summary of the model treatment systems used to develop all proposed limitations and standards.

10. With respect to the general issues remanded by the United States Court of Appeals for the Third Circuit, EPA concludes:

    a. The "age" of facilities has no significant impact on the "cost or feasibility of retrofitting" pollution controls. First, "age" is a relatively meaningless term in the steel industry. It is extremely difficult to define because many plants are continually rebuilt and modernized.

       Whether "first year of production" or "years since last rebuild" is taken as an indicia of plant "age," the data show that "age" has no significant impact on the "feasibility" of retrofitting. Many "old" facilities are served by modern and efficient retrofitted treatment systems. With regard to the impact of plant "age" on the cost of retrofitting, most respondents to EPA questionnaires were unable to estimate "retrofit" costs, reported no retrofit costs, or reported retrofit costs of less than 5% of pollution control costs. Moreover, detailed engineering studies and industry cost estimates for three of the "oldest" plants in the country produced cost estimates similar to EPA's model plant estimates.

However, even assuming that plant "age" does affect the "cost or feasibility of retrofitting," EPA believes that separate subcategorization or relaxed limitations for "older" plants are not justifiable. "Older" plants cause similar pollution problems as "newer" plants, and the need to control these problems would justify the expenditure of reasonable additional "retrofit" costs, if any. Therefore the proposed regulation does not differentiate between "old" and "new" facilities.

b. EPA's cost estimates are sufficiently generous to reflect all costs to be incurred when installing wastewater treatment systems including "site-specific costs". The Agency's cost models now include several "site-specific cost" items not included in prior cost models (See Section III) and incorporate several conservative assumptions. EPA also compared its model plant cost estimates with actual costs reported by the industry including "site-specific costs." Finally, detailed plant-by-plant engineering estimates (cost estimates provided by the industry) for eight plants reveal estimated costs (including "site-specific costs") similar to EPA's model plant cost estimates.

c. The proposed BPT, BCT, BAT, PSES, PSNS, and NSPS limitations in seven subcategories are based upon model treatment and standards systems including recycle systems and mechanical draft cooling towers. The installation of these systems may result in evaporative water losses of about 36 MGD above current losses. However, the environmental benefits of these treatment systems justify the additional evaporative water losses. Recycle and cooling systems are extensively used at steel plants in water-scarce areas and, the Agency concludes the incremental impacts of the proposed regulation on these plants is either minimal or nonexistent.

TABLE I-1

BPT EFFLUENT LIMITATIONS ANALYSIS *

OPERATION			1974 and 1976 BPT EFFLUENT LIMITATIONS (lbs/1000 lbs)									REVISED BPT EFFLUENT LIMITATIONS (lbs/1000 lbs)							
			Discharge Flow Basis (GPT)	TSS	Oil & Grease	Other						Discharge Flow Basis (GPT)	TSS	Oil & Grease	Other				
A	COKEMAKING	BY-PRODUCT	175	0.0365	0.0109	0.0912(a)	0.0219(b)	0.0015(c)	—	—	—	175	0.0750	0.0109 (NC)	0.0912(a) (NC)	0.0219(b) (NC)	0.0015(c) (NC)	—	—
		BEE HIVE	NO DISCHARGE OF PROCESS WASTEWATER POLLUTANTS									—	NO CHANGE						
B	SINTERING		50	0.0104	0.0021	—	—	—	—	—	—	100	0.0208	0.0042	—	—	—	—	—
C	BLAST FURNACE	IRON	125	0.0260	—	0.0535(a)	0.0078(b)	0.0021(c)	—	—	—	—	NO CHANGE						
		FERRO-MANGANESE	250	0.104	—	0.429(a)	0.156(b)	0.0208(c)	—	—	—	—	NO CHANGE						
D	STEELMAKING	B.O.F. (Semi-wet)	NO DISCHARGE OF PROCESS WASTEWATER POLLUTANTS									—	NO CHANGE						
		B.O.F. (Wet)	50	0.0104	—	—	—	—	—	—	—	—	NO CHANGE						
		OPEN HEARTH (Semi-wet)	50	0.0104	—	—	—	—	—	—	—	NO DISCHARGE OF PROCESS WASTEWATER POLLUTANTS							
		OPEN HEARTH (Wet)	50	0.0104	—	—	—	—	—	—	—	110	0.0229	—	—	—	—	—	—
		ELECTRIC ARC FURNACE (Semi-wet)	NO DISCHARGE OF PROCESS WASTEWATER POLLUTANTS									—	NO CHANGE						
		ELECTRIC ARC FURNACE (Wet)	50	0.0104	—	—	—	—	—	—	—	—	NO CHANGE						
E	VACUUM DEGASSING		25	0.0052	—	—	—	—	—	—	—	—	NO CHANGE						
F	CONTINUOUS CASTING		125	0.0260	0.0078	—	—	—	—	—	—	—	NO CHANGE						

TABLE I-1
BPT EFFLUENT LIMITATION ANALYSIS
PAGE 2

OPERATION			1974 and 1976 BPT EFFLUENT LIMITATIONS (lbs/1000 lbs)									REVISED BPT EFFLUENT LIMITATIONS (lbs/1000 lbs)								
			Discharge Flow Basis (GPT)	TSS	Oil & Grease	Other						Discharge Flow Basis (GPT)	TSS	Oil & Grease	Other					
G	HOT FORMING	Primary (CS without scarfing)	692	0.0371	0.0288	—	—	—	—	—	—	—	NO	CHANGE						
		Primary (CS with scarfing)	845	0.0453	0.0352	—	—	—	—	—	—	—	NO	CHANGE						
		Primary (Specialty)	1220	0.0654	0.0508	—	—	—	—	—	—	—	NO	CHANGE						
		Section	2626	0.242	0.1095	—	—	—	—	—	—	—	NO	CHANGE						
		Flat (Hot Strip and Sheet)	4180	0.3308	0.1743	—	—	—	—	—	—	—	NO	CHANGE						
		Flat (Carbon Plate)	4000	0.1668	0.1668	—	—	—	—	—	—	—	NO	CHANGE						
		Flat (Specialty Plate)	9366	0.3760	0.3760	—	—	—	—	—	—	—	NO	CHANGE						
		Pipe & Tube	1002	0.1418	0.0418	—	—	—	—	—	—	—	NO	CHANGE						
H	SCALE REMOVAL	Kolene Descaling	500	0.0521	—	0.0005 (b)	0.0021 (d)	0.0001 (g)	0.0010 (j)	—	—	500	0.0521 (NC)	—	(NL)	0.0021 (d) (NC)	0.0010 (f)	0.0001 (g) (NC)	NOTE: Dissolved Chromium Changed to Total Chromium	
		Hydride Descaling	1200	0.1251	—	0.0013 (b)	0.0050 (d)	0.0003 (g)	0.0025 (j)	—	—	1200	0.125 (NC)	—	0.0013 (b) (NC)	0.0050 (d) (NC)	0.0025 (f)	0.0003 (g) (NC)		
I	PICKLING	Continuous (Neutralization) w/spent pickle liquor	250	0.0521	0.0104 (l)	0.00104 (d)	—	—	—	—	—	—	NO	CHANGE						
		Continuous (Neutralization) w/o spent pickle liquor	225	0.0469	0.0094 (l)	0.00094 (d)	—	—	—	—	—	—	NO	CHANGE						
	I. SULFURIC ACID PICKLING	Continuous (Acid Recovery)	NO DISCHARGE OF PROCESS WASTEWATER POLLUTANTS									—	NO	CHANGE						
		Batch (Neutralization)	CONVERT TO ACID RECOVERY									360	0.0751	0.015 (h)	0.0015 (d)	—	—	—	—	—
		Batch (Acid Recovery)	NO DISCHARGE OF PROCESS GENERATED POLLUTANTS									—	NO	CHANGE						

TABLE I-1
BPT EFFLUENT LIMITATION ANALYSIS
PAGE 3

OPERATION			1974 and 1976 BPT EFFLUENT LIMITATIONS (lbs/1000 lbs)									REVISED BPT EFFLUENT LIMITATIONS (lbs/1000 lbs)								
			Discharge Flow Basis (GPT)	TSS	Oil & Grease	Other						Discharge Flow Basis (GPT)	TSS	Oil & Grease	Other					
	2. HYDROCHLORIC ACID PICKLING	Continuous (Neutralization with Scrubber)	280	0.0584	0.0117 (1)	0.00117 (d)							NO CHANGE							
		Continuous (Neutralization without Scrubber)	230	0.0480	0.00960 (1)	0.00096 (d)							NO CHANGE							
		Continuous (Acid Regeneration with Scrubber)	450	0.0938	0.0187 (1)	0.00187 (d)							NO CHANGE							
		Continuous (Acid Regeneration without Scrubber)	400	0.0834	0.0166 (1)	0.00166 (d)							NO CHANGE							
		Batch (Neutralization with Scrubber)	280	0.0584	0.0117 (1)	0.00117 (d)							NO CHANGE							
		Batch (Neutralization without Scrubber)	230	0.0480	0.00960 (1)	0.00096 (d)							NO CHANGE							
	3. COMBINATION ACID PICKLING	Combination - Continuous	1000	0.104	0.0417 (1)	0.0042 (d)	0.0021 (j)	0.0626 (k)	0.0010 (1)			1000 (NC)	0.104 (NC)	0.0417 (1) (NC)	0.0042 (d) (NC)	0.0021 (f)	0.0626 (3)(k) (NC)	0.0010 (n)	NOTE: Dissolved Chromium and Dissolved Nickel Have Been Changed to Total Chromium and Total Nickel.	
		Combination - Batch Pipe and Tube	700	0.0730	0.0292 (1)	0.0029 (d)	0.0015 (j)	0.0438 (k)	0.0007 (1)			700 (NC)	0.0730 (NC)	0.0292 (1) (NC)	0.00290 (d) (NC)	0.0015 (f)	0.0438 (3)(k) (NC)	0.0007 (n)		
		Combination - Other Batch Operations	200	0.0209	0.0083 (1)	0.0008 (d)	0.0004 (j)	0.0125 (k)	0.0002 (1)			200 (NC)	0.0209 (NC)	0.00830 (1) (NC)	0.00080 (d) (NC)	0.00040 (f)	0.0125 (3)(k) (NC)	0.00020 (n)		
J.	COLD FORMING	Cold Rolling (Recirculation)	25	0.0026	0.00104	0.00011 (2)(d)	—	—	—	—	—		NO CHANGE							
		Cold Rolling (Combination)	400	0.0417	0.0167	0.00167 (2)(d)	—	—	—	—	—		NO CHANGE							
		Cold Rolling (Direct Application)	1000	0.104	0.0417	0.0042 (2)(d)	—	—	—	—	—		NO CHANGE							
		Pipe & Tube (Water)	1002	0.142	0.0418	—	—	—	—	—	—	NO DISCHARGE OF PROCESS WASTEWATER POLLUTANTS								
		Pipe & Tube (Oil)	1002	0.142	0.0418	—	—	—	—	—	—	NO DISCHARGE OF PROCESS WASTEWATER POLLUTANTS								

TABLE I-1
BPT EFFLUENT LIMITATION ANALYSIS
PAGE 4

OPERATION			1974 and 1976 BPT EFFLUENT LIMITATIONS (lbs/1000 lbs)									REVISED BPT EFFLUENT LIMITATIONS (lbs/1000 lbs)								
			Discharge Flow Basis (GPT)	TSS	Oil & Grease	Other						Discharge Flow Basis (GPT)	TSS	Oil & Grease	Other					
K.	ALKALINE CLEANING**		50	0.0052	—	0.0002 (d)	0.0001 (j)	0.00005 (l)	—	—	—	50	0.0052	—	—	—	—	—	—	—
L.	HOT COATING 1. GALVANIZING	Strip/Sheet/ Misc. Products with Scrubbers	1200	0.250	0.0750	0.0250 (e)	0.0150 (f)	0.00010 (g)	—	—	—		NO CHANGE							
		Strip/Sheet/ Misc. Products without Scrubbers	600	0.125	0.0375	0.0125 (e)	0.0075 (f)	0.00005 (g)	—	—	—		NO CHANGE							
		Wire Products and Fasteners with Scrubbers	NO SEPARATE LIMITATIONS PROPOSED FOR THIS SEGMENT									3900	0.813	0.244	0.0813 (e)	0.0163 (f)	0.00033 (g)	—	—	—
		Wire Products and Fasteners without Scrubbers	NO SEPARATE LIMITATIONS PROPOSED FOR THIS SEGMENT									2400	0.500	0.150	0.050 (e)	0.010 (f)	0.00020 (g)	—	—	—
	2. TERNE	Without Scrubbers	600	0.125	0.0375	0.00125 (h)	0.0125 (i)	—	—	—	—		NO CHANGE							
		With Scrubbers	1200	0.250	0.0750	0.0025 (h)	0.0250 (i)	—	—	—	—		NO CHANGE							
	3. OTHER COATINGS	Strip/Sheet/ Misc. Products with Scrubbers	NO SEPARATE LIMITATIONS PROPOSED FOR THIS SEGMENT									1200	0.250	0.0750	0.0150 (e)	0.0010 (f)	0.0025 (h)	0.0025 (o)	—	—
		Strip/Sheet/ Misc. Products without Scrubbers	NO SEPARATE LIMITATIONS PROPOSED FOR THIS SEGMENT									600	0.125	0.0375	0.0075 (e)	0.0005 (f)	0.0013 (h)	0.0013 (o)	—	—
		Wire Products and Fasteners with Scrubbers	NO SEPARATE LIMITATIONS PROPOSED FOR THIS SEGMENT									3900	0.813	0.244	0.049 (e)	0.0081 (f)	0.0081 (h)	0.0081 (o)	—	—
		Wire Products and Fasteners without Scrubbers	NO SEPARATE LIMITATIONS PROPOSED FOR THIS SEGMENT									2400	0.500	0.150	0.030 (e)	0.0050 (f)	0.0050 (h)	0.0050 (o)	—	—

NOTE: pH is also regulated in all subcategories and is limited to 6.0-9.0 standard units.

LEGEND

* All values represent 30-day average limitations. Maximum limits are 3 times the 30-day average value.
** Original BPT limitations were only for continuous plants. Revised limits apply to both batch and continuous operations.
(1) This load is allowed only when these wastes are treated in combination with cold rolling mill wastes.
(2) This load is allowed only when these wastes are treated in combination with cold rolling mill wastes.
(3) This load is allowed only when hydrofluoric acids are used at the mill.

NL - No limit proposed
NC - No change
(a) Ammonia (as N)
(b) Cyanide
(c) Phenol (4-AAP)
(d) Dissolved Iron
(e) Zinc
(f) Chromium (Total)
(g) Chromium (Hexavalent)
(h) Lead
(i) Tin
(j) Chromium, Dissolved
(k) Fluoride
(l) Nickel, Dissolved
(m) Copper, Dissolved
(n) Nickel, Total
(o) Cadmium (Limited only at cadmium coating operations)

TABLE I-2

COST SUMMARY - BY SUBCATEGORY
IRON AND STEEL INDUSTRY

Subcategory	Treatment Level	Costs (Millions of 7/1/78 Dollars) In-Place Capital(1)	Required Capital	Total Annual
A. Cokemaking	BPT/BAT Feed	178.8	125.2	105.0
	BAT-1(2)	11.9	45.4	9.8
B. Sintering	BPT/BAT Feed	46.3	27.9	37.3
	BAT-3	2.0	11.3	2.6
C. Ironmaking	BPT/BAT Feed	351.9	122.3	95.3
	BAT-4(3)	4.3	20.6	4.9
D. Steelmaking	BPT/BAT Feed	127.8	24.0	38.0
	BAT-2	0.9	14.3	3.6
E. Vacuum Degassing	BPT/BAT Feed	9.9	20.4	7.7
	BAT-1	0.6	1.0	0.2
F. Continuous Casting	BPT/BAT Feed	60.7	41.9	23.9
	BAT-1	0	4.4	0.8
G. Hot Forming	BPT/BAT Feed	541.7	135.3	-103.7
	BAT-1	100.8	434.7	110.8
H. Scale Removal	BPT/BAT Feed	3.8	3.7	2.1
	BAT-1	0.1	3.1	0.6
I. Acid Pickling	BPT/BAT Feed	138.4	170.5	68.0
	BAT-1(4)	0	27.7	8.6
J. Cold Forming	BPT/BAT Feed	31.2	36.9	12.6
	BAT-2(5)	0	24.0	4.5
K. Alkaline Cleaning	BPT/BAT Feed	6.6	7.1	4.2
	BAT(6)	0	0	0
L. Hot Coating	BPT/BAT Feed	28.2	35.9	12.8
	BAT-1	3.9	7.2	3.3
TOTALS	BPT/BAT Feed	1,525.2	751.1	303.2
	BAT	124.5	593.7	149.8

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(1) Basis: facilities in place or committed as of 1/1/78.
(2) BAT for beehive cokemaking operations.
(3) Costs are based on 60% of the plants at BAT-1, and 40% of the plants at the BAT-4 level.
(4) BPT for Sulfuric Acid recovery operations.
(5) BAT is the same as BPT for cold forming pipe and tube operations. Cold rolling cost basis is BAT-1.
(6) No BAT is being proposed for the alkaline cleaning subcategory.

TABLE I-3

EFFLUENT LOAD SUMMARY
IRON & STEEL INDUSTRY-BY SUBCATEGORY

Subcategory	Treatment Level	Discharge Flow(MGD)	Effluent Loadings (tons/year)		
			Toxic Organics[1]	Toxic Metals	Others
A. Cokemaking	Raw	36.9	26,306.0	151.6	76,082
	BPT/BAT Feed	49.0	770.0	58.2	15,343
	BAT-1[2]	34.1	211.8	23.8	2,907
B. Sintering	Raw	122.6	84.0	616.0	1,185,500
	BPT/BAT Feed	8.4	37.8	24.3	1,151
	BAT-3	6.3	4.7	6.7	288
C. Ironmaking	Raw	1,036.8	20,088.0	41,280.0	3,029,860
	BPT/BAT Feed	40.5	1,074.4	385.9	10.664
	BAT-4[3]	9.2	14.4	15.6	366
D. Steelmaking	Raw	284.4	15.5	25,130.2	1,274,460
	BPT/BAT Feed	13.5	0.7	127.0	1,667
	BAT-2	13.5	0.7	25.0	561
E. Vacuum Degassing	Raw	57.1	0	976.0	6,955
	BPT/BAT Feed	1.0	0	1.8	77
	BAT-1	1.0	0	0.7	33
F. Continuous Casting	Raw	238.0	0	590.5	30,791
	BPT/BAT Feed	1.8	0	4.3	173
	BAT-1	1.8	0	1.3	53
G. Hot Forming	Raw	4,188.0	0	34,820.0	6,289,895
	BPT/BAT Feed	2,670.0	0	1,669.7	101,822
	BAT-1	167.5	0	90.8	3,632
H. Scale Removal	Raw	0.9	0.2	375.6	1,387
	BPT/BAT Feed	0.9	0.1	2.1	24
	BAT-1	0.9	0.1	0.7	14
I. Acid Pickling	Raw	172.7	4.6	31,918.0	615,548
	BPT/BAT Feed	94.9	1.7	97.3	4,946
	BAT-1[4]	17.6	0.3	17.8	910
J. Cold Forming	Raw	87.3	279.7	186.4	2,106,264
	BPT/BAT Feed	39.6	267.1	37.7	2,013
	BAT-2[5]	39.6	14.8	33.8	1,151
K. Alkaline Cleaning	Raw	2.9	0.2	0.8	1,583
	BPT/BAT Feed	2.9	0.2	0.8	108
	BAT[6]	2.9	0.2	0.8	108
L. Hot Coating	Raw	34.7	2.3	3,447.0	7,088
	BPT/BAT Feed	34.7	1.2	335.0	2,502
	BAT-1	7.2	0.1	4.6	276
TOTALS	Raw	6,262.3	46,780.5	139,492.1	14,625,413
	BPT/BAT Feed	2,947.7	2,153.2	2,744.1	140,490
	BAT	301.6	247.1	221.6	10,299

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(1) Includes total cyanide and phenolic compounds (4AAP).
(2) BPT for Beehive operations.
(3) Loads based on 60% of the plants at BAT-1, and 40% at BAT-4.
(4) BPT for Acid Recovery (Sulfuric) operations.
(5) BPT for Cold Working Pipe & Tube and BAT-1 for Direct Application Cold Rolling operations.
(6) No BAT is being proposed for the alkaline cleaning subcategory.

TABLE I-4

BAT EFFLUENT LIMITATION SUMMARY
IRON AND STEEL INDUSTRY

Subcategory	Alternative Selected	Discharge Flow (GPT)	PROPOSED BAT POLLUTANTS - MONTHLY AVERAGE UNLESS OTHERWISE NOTED (kg/kkg x 10^5)											
			Ammonia	Phenols (4AAP)	Chlorine	Benzene (004)	Naphthalene (055)	Benzo(a) Pyrene (073)	Chromium (119)	Copper (120)	Cyanide(T) (121)	Lead (122)	Nickel (124)	Zinc (128)
A Cokemaking	BAT-1	153	957.0(1)	1.60	-	3.19	0.638	1.28	-	-	160.0(2)	-	-	-
B. Sintering	BAT-3	75	31.3	3.13	15.6*	-	-	-	-	-	7.82	3.13	-	3.13
C. Ironmaking	BAT-4	70	29.2	2.92	14.6*	-	-	-	-	-	29.2	7.30	-	8.76
D. Steelmaking														
1. BOF														
a. Semi-Wet	BPT	0	-	-	-	-	-	-	-	-	-	-	-	-
b. Wet-SC	BAT-1	50	-	-	-	-	-	-	2.09	-	-	6.26	-	6.26
c. Wet-OC	BAT-1	65	-	-	-	-	-	-	6.78	-	-	6.78	-	8.13
2. Open Hearth														
a. Semi-Wet	BPT	0	-	-	-	-	-	-	-	-	-	-	-	-
b. Wet	BAT-2	110	-	-	-	-	-	-	4.59	-	-	6.88	-	13.8
3. Elec. Arc Furnace														
a. Semi-Wet	BPT	0	-	-	-	-	-	-	-	-	-	-	-	-
b. Wet	BAT-2	50	-	-	-	-	-	-	3.13	-	-	6.26	-	7.30
E. Vacuum Degassing	BAT-1	25	-	-	-	-	-	-	1.04	-	-	1.04	-	1.04
F. Continuous Casting	BAT-1	25	-	-	-	-	-	-	1.04	-	-	1.04	-	1.04
G. Hot Forming														
1. Primary														
a. wo/s	BAT-1	90	-	-	-	-	-	-	3.75	-	-	3.75	-	3.75
b. w/s	BAT-1	140	-	-	-	-	-	-	5.84	-	-	5.84	-	5.84

TABLE I-4
BAT EFFLUENT LIMITATION SUMMARY
IRON AND STEEL INDUSTRY
PAGE 2

Subcategory	Alternative Selected	Discharge Flow (GPT)	PROPOSED BAT POLLUTANTS - MONTHLY AVERAGE UNLESS OTHERWISE NOTED (kg/kkg x 10^5) Fluoride	Chromium (119)	Copper (120)	Cyanide (121)	Lead (122)	Nickel (124)	Zinc (128)	
2. Section										
a. Carbon	BAT-1	200	-	8.34	-	-	8.34	-	8.34	
b. Specialty	BAT-1	130	-	5.42	-	-	5.42	-	5.42	
3. Flat										
a. Hot Strip	BAT-1	260	-	10.8	-	-	10.8	-	10.8	
b. Carbon Plate	BAT-1	140	-	5.84	-	-	5.84	-	5.84	
c. Specialty Plate	BAT-1	60	-	2.50	-	-	2.50	-	2.50	
4. Pipe & Tube	BAT-1	220	-	9.17	-	-	9.17	-	9.17	
H. Scale Removal										
1. Kolene	BAT-1	320	-	13.3	-	-	-	-	-	
2. Hydride	BAT-1	100	-	4.17	-	10.4	4.17	-	-	
I. Acid Pickling										
1. Sulfuric Acid										
a. Acid Recovery	BPT	0	-	-	-	-	-	-	-	
b. Batch Neut.	BAT-1	70	-	2.92	-	-	2.92	-	2.92	
c. Cont. Neut.	BAT-1	55	-	2.29	-	-	2.29	-	2.29	
2. Hydrochloric Acid										
a. Acid Reg.	BAT-1	70	-	2.92	-	-	2.92	-	2.92	
b. Batch Neut.	BAT-1	90	-	3.75	-	-	3.75	-	3.75	
c. Cont. Neut.	BAT-1	55	-	2.29	-	-	2.29	-	2.29	
3. Combination Acid										
a. Batch	BAT-1	105	6.57.0(3)	4.38	4.38	-	-	8.76	-	
b. Continuous	BAT-1	335	2,100.0(3)		14.0	14.0	-	-	27.9	-

TABLE I-4
BAT EFFLUENT LIMITATION SUMMARY
IRON AND STEEL INDUSTRY
PAGE 3

		PROPOSED BAT POLLUTANTS - MONTHLY AVERAGE UNLESS OTHERWISE NOTED (kg/kkg x 10^5)								
Subcategory	Alternative Selected	Discharge Flow (GPT)	1,1,1-Trichloroethane (011)	2-Nitro-Phenol (057)	Anthracene (078)	Tetrachloroethylene (085)	Cadmium (118)	Chromium (119)	Lead (122)	Zinc (128)
J. Cold Forming										
1. Cold Rolling										
a. Recirc.	BAT-2	25	1.04	0.261	0.104	0.521	-	1.04	1.04	1.04
b. Combination	BAT-2	250	10.4	2.61	1.04	5.21	-	10.4	10.4	10.4
c. Direct Application	BAT-1	400	-	-	-	-	-	16.7	16.7	16.7
2. Pipe & Tube	BPT	0	-	-	-	-	-	-	-	-
K. Alkaline Cleaning	BPT	50	-	-	-	-	-	-	-	-
L. Hot Coating										
1. Galvanizing										
a. Strip/Sheet/Misc.Prod. wo/scrubbers	BAT-1	150	-	-	-	-	-	6.26	6.26	6.26
b. Strip/Sheet Misc. Prod. w/scubbers	BAT-1	200	-	-	-	-	-	8.34	8.34	8.34
c. Wire Prod. & Fasteners wo/scrubbers	BAT-1	600	-	-	-	-	-	25.0	25.0	25.0
d. Wire Prod. & Fasteners w/scrubbers	BAT-1	750	-	-	-	-	-	31.3	31.3	31.3
2. Terne										
a. Without Scrubbers	BAT-1	150	-	-	-	-	-	6.26	6.26	6.26
b. With Scrubbers	BAT-1	200	-	-	-	-	-	8.34	8.34	8.34
3. Other Metals										
a. Strip/Sheet Misc.Prod. wo/scrubbers	BAT-1	150	-	-	-	-	6.26(4)	6.26	6.26	6.26
b. Strip/Sheet Misc.Prod w/scrubbers	BAT-1	200	-	-	-	-	8.34(4)	8.34	8.34	8.34
c. Wire Prod. & Fasteners wo/scrubbers	BAT-1	600	-	-	-	-	25.0(4)	25.0	25.0	25.0
d. Wire Prod. & Fasteners w/scrubbers	BAT-1	750	-	-	-	-	31.3(4)	31.3	31.3	31.3

TABLE I-4
BAT EFFLUENT LIMITATION SUMMARY
IRON AND STEEL INDUSTRY
PAGE 4

Footnotes

(1) Average ammonia limits for physical/chemical (see cokemaking volume for definition) treatment systems is 0.0258 kg/kkg.
(2) The stated cyanide limitation applies only to biological treatment systems.
(3) Fluoride is limited only at those combination acid pickling operations that use hydrofluoric acid.
(4) Cadmium is limited only at those operations that practice cadmium coating.
*: Maximum limit only.

NOTE: Maximum limitations are three times the average limits, except as noted below.

A. ♦ Cokemaking:

	Multiplication Factors
Max CN = 3.19 x 10^{-3} kg/kkg	2.0
Max Phenol = 6.38 x 10^{-3} kg/kkg	4.0
Max NH_3-N = 5.10 x 10^{-2} kg/kkg	5.3
Max Benzene = 6.38 x 10^{-5} kg/kkg	2.0
Max Naphthalene = 1.28 x 10^{-5} kg/kkg	2.0
Max Benzo(a)pyrene = 2.56 x 10^{-5} kg/kkg	2.0

B. Maximum for nickel equals 2.25 times the average values.

TABLE I-5

BCT EFFLUENT LIMITATION SUMMARY
IRON AND STEEL INDUSTRY

Subcategory	BCT Limitations (kg/kkg)			
	Total Suspended Solids		Oil and Grease	
	Ave.	Max.	Ave.	Max.
A. Cokemaking				
1. By-Product	0.0128	0.0255	-	0.00638
2. Beehive	Zero Discharge of Process Generated Pollutants			
B. Sintering	0.00469	0.0125	-	0.00313
C. Ironmaking	0.00439	0.0117	-	0.00290
D. Steelmaking				
1. BOF				
a. Semi-Wet	Zero Discharge of Process Generated Pollutants			
b. Wet-SC	0.00313	0.00834	-	-
c. Wet-OC	0.00407	0.0108	-	-
2. Open Hearth				
a. Semi-Wet	Zero Discharge of Process Generated Pollutants			
b. Wet	0.00688	0.0183	-	-
3. Electric Furnace				
a. Semi-Wet	Zero Discharge of Process Generated Pollutants			
b. Wet	0.0104	0.0313	-	-
E. Vacuum Degassing	0.00520	0.0156	-	-
F. Continuous Casting	0.00156	0.00417	-	0.00104
G. Hot Forming				
1. Primary				
a. wo/scarfers	0.00563	0.0150	-	0.00375
b. w/scarfers	0.00878	0.0234	-	0.0136

TABLE I-5
BCT EFFLUENT LIMITATION SUMMARY
IRON AND STEEL INDUSTRY
PAGE 2

Subcategory	Total Suspended Solids		Oil and Grease	
	Ave.	Max.	Ave.	Max.
2. Section				
a. Carbon	0.0125	0.0333	-	0.00834
b. Specialty	0.00813	0.0217	-	0.00542
3. Flat				
a. Hot Strip & Sheet	0.0163	0.0435	-	0.0108
b. Carbon Plate	0.00878	0.0234	-	0.00584
c. Specialty Plate	0.00375	0.0100	-	0.00250
4. Pipe & Tube	0.0138	0.0368	-	0.00917
H. Scale Removal				
1. Kolene	0.0521	0.156	-	-
2. Hydride	0.00626	0.0167	-	-
I. Acid Pickling				
1. Sulfuric				
a. Acid Recovery	Zero Discharge of Process Generated Pollutants			
b. Batch Neut.	0.0750	0.225	0.0150(1)	0.0450(1)
c. Cont. Neut. w/spent pickle liquor	0.0521	0.156	0.0104(1)	0.0312(1)
d. Cont. Neut. wo/spent pickle liquor	0.0469	0.141	0.0094(1)	0.0282(1)

TABLE I-5
BCT EFFLUENT LIMITATION SUMMARY
IRON AND STEEL INDUSTRY
PAGE 3

Subcategory	Total Suspended Solids		Oil and Grease	
	Ave.	Max.	Ave.	Max.
2. Hydrochloric				
a. Cont. Regeneration	0.00438	0.0117	-	0.00292(1)
b. Cont. Neutralization	0.00344	0.00917	-	0.00229(1)
c. Batch Neut. w/s	0.0584	0.175	0.0117(1)	0.0351(1)
d. Batch Neut. wo/s	0.0480	0.144	0.0096(1)	0.0288(1)
3. Combination				
a. Continuous	0.104	0.312	0.0417(1)	0.125(1)
b. Batch Pipe & Tube	0.0730	0.219	0.0292(1)	0.0876(1)
c. Batch Other	0.0209	0.0627	0.00830(1)	0.0249(1)
J. Cold Forming				
1. Cold Rolling				
a. Recirculation	0.00260	0.00780	0.00104	0.00312
b. Combination	0.0156	0.0416	-	0.0104
c. Direct Application	0.0250	0.0667	-	0.0167
2. Pipe & Tube	Zero Discharge of Process Generated Pollutants			
K. Alkaline Cleaning	0.0052	0.0160	-	-
L. Hot Coating				
1. Galvanizing				
a. s/s w/s	0.0125	0.0334	-	0.00834
b. s/s wo/s	0.00938	0.0250	-	0.00626
c. Wire w/s	0.0469	0.125	-	0.0313
c. Wire wo/s	0.0375	0.100	-	0.0250

TABLE I-5
BCT EFFLUENT LIMITATION SUMMARY
IRON AND STEEL INDUSTRY
PAGE 4

Subcategory	Total Suspended Solids		Oil and Grease	
	Ave.	Max.	Ave.	Max.
2. Terne				
a. w/s	0.0125	0.0334	-	0.00834
b. wo/s	0.125	0.375	0.0375	0.113
3. Other Metals				
a. s/s w/s	0.0125	0.0334	-	0.00834
b. s/s wo/s	0.0188	0.0375	-	0.00626
c. Wire w/s	0.813	2.439	0.244	0.732
d. Wire wo/s	0.0751	0.150	-	0.0250

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(1) Load allowed only when treated jointly with cold rolling wastes.

NOTE: pH is also regulated at BCT and is limited to 6.0 to 9.0 units.

KEY TO ABBREVIATIONS

SC : Suppressed Combustion
OC : Open Combustion
wo : Without
w : With
s/s: Strip & Sheet

TABLE I-6

STEEL INDUSTRY
OPTIONS AND REGULATED POLLUTANTS

Subcategory	Options No.	Options GPT	BCT(1) TSS	BCT(1) O&G	BAT NH_3N	BAT Chlorine	BAT 4AAP PHE	BAT Toxic Organics (4)	BAT Toxic Organics (55)	BAT Toxic Organics (73)	BAT Cr(T) (119)	BAT CN(T) (121)	BAT Pb (122)	BAT Zn (128)
			Monthly Average Concentrations (mg/l)											
A. Cokemaking	1	153	20	10*	15	-	0.025	0.05	0.01	0.02	-	2.5	-	-
B. Sintering	3(2)	75	15	10*	1.0	0.5*	0.1	-	-	-	-	0.25	0.1	0.1
C. Ironmaking	4(2)	70	15	10*	1.0	0.5*	0.1	-	-	-	-	1.0	0.25	0.30
D. Steelmaking														
BOF-SC	2	50	15	-	-	-	-	-	-	-	0.1	-	0.30	0.30
BOF-OC	2	65	15	-	-	-	-	-	-	-	0.25	-	0.25	0.30
OH-Wet	2	110	15	-	-	-	-	-	-	-	0.1	-	0.15	0.30
EAF-Wet	2	50(50)	50(3)	-	-	-	-	-	-	-	0.15	-	0.30	0.35
E. Vacuum Degassing	1	25(25)	50(3)	-	-	-	-	-	-	-	0.1	-	0.1	0.1
F. Continuous Casting	1	25	15	10*	-	-	-	-	-	-	0.1	-	0.1	0.1

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STEEL INDUSTRY
OPTIONS AND REGULATED POLLUTANTS
PAGE 2

			Monthly Average Concentrations (mg/l)													
			$BCT^{(1)}$		BAT											
	Options						Toxic Organics									
Subcategory	No.	GPT	TSS	O&G	FL	Fe(d)	(11)	(57)	(78)	(85)	Cr(T) (119)	Cu (120)	CN(T) (121)	Pb (122)	Ni(T) (124)	Zn (128)
G. Hot Forming	1	-	15	10*	-	-	-	-	-	-	0.1	-	-	0.1	-	0.1
H. Scale Removal																
Kolene	1	320(500)	$25^{(3)}$	-	-	-	-	-	-	-	0.1	-	-	-	-	-
Hydride	1	100	15	-	-	-	-	-	-	-	0.1	-	0.25	0.1	-	-
I. Acid Pickling																
SAP-Batch	1	70(360)	$50^{(3)}$	$10^{(3)}$	-	-	-	-	-	-	0.1	-	-	0.1	-	0.1
SAP-Cont.	1	55(250)	$50^{(3)}$	$10^{(3)}$	-	-	-	-	-	-	0.1	-	-	0.1	-	0.1
HAP-Batch	1	90(560)	$50^{(3)}$	$10^{(3)}$	-	-	-	-	-	-	0.1	-	-	0.1	-	0.1
HAP-Cont.-Regen.	1	70	15	10*	-	-	-	-	-	-	0.1	-	-	0.1	-	0.1
HAP-Cont.-Neut.	1	55	15	10*	-	-	-	-	-	-	0.1	-	-	0.1	-	0.1
CAP-Batch	1	$105(700^{(4)})$	$25^{(3)}$	$10^{(3)}$	15	-	-	-	-	-	0.1	0.1	-	-	0.2	-
CAP-Cont.	1	335(1000)	$25^{(3)}$	$10^{(3)}$	15	-	-	-	-	0.1	0.1	-	-	0.2	-	
J. Cold Forming																
CR-Rec	$2^{(5)}$	25(25)	$25^{(3)}$	$10^{(3)}$	-	-	0.1	0.025	0.01	0.05	0.1	-	-	0.1	-	0.1
CR-Comb.	$2^{(5)}$	250	15	10*	-	-	0.1	0.025	0.01	0.05	0.1	-	-	0.1	-	0.1
CR-D.A.	1	400	15	10*	-	-	-	-	-	-	0.1	-	-	0.1	-	0.1
CF-Pipe & Tube	BPT	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
K. Alkaline Cleaning	BPT	50	25	-	-	-	-	-	-	-	-	-	-	-	-	-

TABLE I-6
STEEL INDUSTRY
OPTIONS AND REGULATED POLLUTANTS
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	Options		Monthly Average Concentrations (mg/l)					
			BCT$^{(1)}$		BAT			
Subcategory	No.	GPT	TSS	O&G	Cd (118)	Cr(T) (119)	Pb (122)	Zn (128)
L. Hot Coating								
1. Galvanizing								
Strip-Sheet w/FHS	1	200	25	10*	-	0.1	0.1	0.1
Strip-Sheet wo/FHS	1	150	25	10*	-	0.1	0.1	0.1
Wire w/FHS	1	750	25	10*	-	0.1	0.1	0.1
Wire wo/FHS	1	600	25	10*	-	0.1	0.1	0.1
2. Terne								
w/FHS	1	200	25	10*	-	0.1	0.1	0.1
wo/FHS	1	150(150)	25$^{(3)}$	10$^{(3)}$	-	0.1	0.1	0.1
3. Other Coatings								
Strip-Sheet w/FHS	1	200	25	10*	0.1$^{(6)}$	0.1	0.1	0.1
Strip-Sheet wo/FHS	1	150	25	10*	0.1$^{(6)}$	0.1	0.1	0.1
Wire w/FHS	1	750(750)	25$^{(3)}$	10$^{(3)}$	0.1$^{(6)}$	0.1	0.1	0.1
Wire wo/FHS	1	600	25	10*	0.1$^{(6)}$	0.1	0.1	0.1

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* : Daily maximum limitation only, as shown.
(): Flow in parentheses is the flow basis for proposed BPT limits.
(1) pH also limited at 6-9.
(2) Options using sulfide.
(3) BCT failed in this category. Limits for conventional pollutant based on the BPT concentration shown and flow in parentheses.
(4) BCT limits for batch-pipe and tube operations are based on 700 gal/ton. BCT limits for batch-other operations are based on 200 gal/ton.
(5) Limitations based on BAT-2 technology. Costs are based on BAT-1 systems.
(6) Limited only at cadmium coating operations.

TABLE I-7

IRON & STEEL TREATMENT MODEL TECHNOLOGIES

Subcategory	Levels of Treatment					
	BPT	BAT	BCT	NSPS	PSNS	PSES
A. Cokemaking						
1. By-product	Fixed still, recycle final cooler, settling basin, acid neutralization, single stage bio-oxidation, clarifier, vacuum filter.	Extended bio-oxidation recycle of barometric condenser, clarifier, filter.	(3)	(4)	(4)	(4)
2. Beehive	Settling basin, 100% recycle	(2)	(2)	(2)	(1)	(1)
B. Sintering	Polymer, thickener, vacuum filter, 93% recycle, acid neutralization	95% recycle, lime addition, alkaline chlorination, clarifier, acid neutralization (from BPT (system), filter, dechlorination.	95% recycle, filter	(4)	(4)	(4)
C. Ironmaking	Polymer, thickener, vacuum filter, cooling tower, 96% recycle	98% recycle, lime addition, alkaline chlorination, clarifier, acid neutralization,(7) filter, dechlorination	98% recycle clarifier	(4)	(4)	(4)
D. Steelmaking						
All semi-wet operations	Lime neutralization (open hearth operations only) polymer, clarifier/thickener, vacuum filter, 100% recycle	(1)	(2)	(2)-for BOF, EAF (1)-for OH	(5)	(2)
Basic Oxygen Furnace (Wet)	Polymer, clarifier/thickener, vacuum filter, 95% recycle, acid neutralization	Lime neutralization, inclined plate separator, filter, acid neutralization (from BPT system)	Filter	(4)	(4)	(4)
Open Hearth Furnace (Wet)	Lime neutralization & polymer addition, clarifier/thickener, vacuum filter, 94% recycle	Lime addition, inclined plate separator, filter	Filter	(1)	(1)	(4)
Electric Arc Furnace (Wet)	Polymer, clarifier/thickener, vacuum filter, 98% recycle	Lime addition, inclined plate separator, filter				

TABLE I-7
IRON & STEEL TREATMENT MODEL TECHNOLOGIES
PAGE 2

Subcategory	Levels of Treatment					
	BPT	BAT	BCT	NSPS	PSNS	PSES
E. Vacuum Degassing	Scale pit, cooling tower, 98% recycle	Filter	(2)	(4)	(4)	(4)
F. Continuous Cooling	Scale pit, 96% recycle, flat bed filter, cooling tower	99% recycle, Filter	(3)	Scale pit, 99% recycle, flat bed filter, cooling tower	(5)	(2)
G. Hot Forming						
Model 1	Scale pit, 50% recycle, clarifier, vacuum filter, filter	Cooling tower, 96% recycle	(3)	Scale pit, recycle, roughing clarifier, vacuum filter, cooling tower, recycle filter blowdown	(5)	(5)
Model 2	Scale pit, clarifier, vacuum filter, filter	Cooling tower, 96% recycle	(3)	Scale pit, recycle, roughing clarifier, vacuum filter, cooling tower, recycle filter blowdown	(5)	(5)
Model 3	Scale pit, 50% recycle, settling lagoon	Cooling tower, 96% recycle, filter	(3)	Scale pit, recycle, roughing clarifier, vacuum filter, cooling tower, recycle filter blowdown	(5)	(5)
H. Scale Removal						
1. Kolene	Oil skimming, acid addition, chromium, reduction, lime, polymer, thickener, vacuum filter	Filter	(2)	(4) (except settling basin in place of thickener)	(5)	(5)
2. Hydride	Cyanide oxidation, acid & polymer addition, thickener, vacuum filter	Filter	(3)	(4) (except settling basin in place of thickener)	(5)	(5)

TABLE I-7
IRON & STEEL TREATMENT MODEL TECHNOLOGIES
PAGE 3

Subcategory	Levels of Treatment					
	BPT	BAT	BCT	NSPS	PSNS	PSES
I. Acid Pickling						
1. Sulfuric a. Neutralization	Spent pickle liquor storage tank, FHS recycle, equalization of SPL, rinse water and fume hood scrubber blowdown, lime & polymer addition, aeration, settling basin	Cascade Rinse	(2)	Acid recovery system (acid discharge)	(5)	(4) (except clarifier & vacuum filter in place of settling basin)
b. Acid Recovery	Spent acid storage system, cascade rinse, FHS recycle, acid recovery system (zero discharge)	(2)	(2)	(2)	(2)	(2)
2. Hydrochloric a. Neutralization	Spent pickle liquor storage tank, FHS recycle, equalization of SPL, rinse water and fume hood scrubber blowdown, lime & polymer addition, aeration, thickener, vacuum filter	Cascade Rinse	Batch-(2) Continuous-(2) plus a filter	(4) (except clarifier in place of thickener)	(5)	(5)
b. Acid Regeneration	Spent acid storage tank, acid regeneration systems, FHS recycle, equalization tank, lime & polymer addition, aeration, thickener, vacuum filter	Cascade Rinse, AVS recycle	(3) plus a filter	(4) (except clarifier in	(5)	(5)
3. Combination	Spent pickle liquor storage tank, FHS recycle, equalization of SPL, rinse water and fume hood scrubber blowdown, oil skimmer, lime & polymer, clarifier, vacuum filter	Cascade Rinse	(2)	(4)	(5)	(4) (except no oil skimmer is provided)

TABLE I-7
IRON & STEEL TREATMENT MODEL TECHNOLOGIES
PAGE 4

Subcategory	Levels of Treatment					
	BPT	BAT	BCT	NSPS	PSNS	PSES
J. Cold Forming						
1. Cold Rolling	Alum, acid (for emulsion breaking), lime & polymer, air flotation, settling basin	Filter	Recirculation: (2) Direct application and combination (3)	(4) and the requirement all new mills will be of the recirculation type	(5)	(4)
2. Pipe & Tube						
a. Water	Scale pit, oil skimmer, 100% recycle	(1)	(2)	(2)	(6)	(6)
b. Oil	Scale pit, oil skimmer, recycle waste oil storage tank (contractor removal as required)	(2)	(2)	(2)	(2)	(2)
K. Alkaline Cleaning	Equalization tank with oil skimmer, acid & polymer, thickener, vacuum filter	(1)	(2)	Equalization tank with oil skimmer, acid, polymer, aeration, settling basin, vacuum filter, filter	(6)	(6)
L. Hot Coating	Lime & polymer, thickener, vacuum filter	FHS recycle, Cascade Rinse	Same as BAT plus a filter (8) Same as BPT (9) Same as BAT (10)	(4)	(4)	(4)

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(1) No standards/limitations are presently proposed; therefore, no treatment model considered.
(2) Same as BPT.
(3) Same as BAT.
(4) Same as BPT plus BAT.
(5) Same as NSPS.
(6) Only general pretreatment standards are proposed.
(7) Approximately 60% of the iron making plants are expected to install 98% recycle and slag evaporation in place of BAT.
(8) Applies to all galvanizing operations with and without scrubber, terne and other metals for sheet and strip operations with scrubbers.
(9) Applies to all other metal coating operations without scrubbers.
(10) Applies to terne sheet and strip operations without scrubbers, other metal coating operations, wire products and fasteners with scrubbers.
SPL: Spent Pickle Liquor
AVS: Absorber Vent Scrubber
FHS: Fume Hood Scrubber

VOLUME I

SECTION II

INTRODUCTION

I. Legal Authority

The regulation which this Development Document supports is proposed by EPA under authority of Sections 301, 304, 306, 307 and 501 of the Clean Water Act (the Federal Water Pollution Control Act Amendments of 1972, 33 U.S.C §§ 1251 *et seq.*, as amended by the Clean Water Act of 1977, P.L. 95-217)(the "Act"). This regulation is also being proposed in response to the "Settlement Agreement" in *Natural Resources Defense Council, Inc., et al. v Train*, 8 ERC 2120 (D.D.C. 1976), *modified*, 12 ERC 1833 (D.D.C. 1979).

II. Background

A. The Clean Water Act

The Federal Water Pollution Control Act Amendments of 1972 established a comprehensive program to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters," Section 101(a). By July 1, 1977, existing industrial dischargers were required to achieve "effluent limitations requiring the application of the best practicable control technology currently available" (BPT), Section 301(b)(1)(A); and, by July 1, 1983, these dischargers were required to achieve "effluent limitations requiring the application of the best available technology economically achievable...which will result in reasonable further progress toward the national goal of eliminating the discharge of all pollutants" (BAT), Section 301(b)(2)(A). New industrial direct dischargers were required to comply with Section 306 new source performance standards (NSPS) based on best available demonstrated technology; and new and existing dischargers to publicly owned treatment works (POTWs) were subject to pretreatment standards under Sections 307(b) and (c) of the Act. While the requirements for direct dischargers were to be incorporated into National Pollutant Discharge Elimination System (NPDES) permits issued under Section 402 of the Act, pretreatment standards were made enforceable directly against dischargers to POTWs (indirect dischargers).

Although Section 402(a)(1) of the 1972 Act authorized the setting of requirements for direct dischargers on a case-by-case basis, Congress intended that, for the most part, control requirements would be based on regulations promulgated by the Administrator of EPA. Section 304(b) of the Act required the Administrator to promulgate regulations providing guidelines for effluent limitations setting forth the degree of effluent reduction attainable through the application of BPT and BAT. Moreover, Sections 304(c) and 306 of the Act required promulgation of regulations for NSPS, and Sections 304(f), 307(b), and 307(c) required promulgation of regulations for pretreatment standards. In addition to these regulations for designated industry categories, Section 307(a) of the Act required the Administrator to promulgate effluent standards applicable to all dischargers of toxic pollutants. Finally, Section 501(a) of the Act authorized the Administrator to prescribe any additional regulations "necessary to carry out his functions" under the Act.

EPA was unable to promulgate many of these regulations by the dates contained in the Act. In 1976, EPA was sued by several environmental groups, and in settlement of this lawsuit, EPA and the plaintiffs executed a "Settlement Agreement" which was approved by the Court. This Agreement required EPA to develop a program and adhere to a schedule for promulgating, for 21 major industries, BAT effluent limitations guidelines, pretreatment standards, and new source performance standards for 65 "priority" pollutants and classes of pollutants. See Natural Resources Defense Council, Inc. v. Train, 8 ERC 2120 (D.D.C. 1976), as modified 12 ERC 1833 (D.D.C. 1979).

On December 27, 1977, the President signed into law the Clean Water Act of 1977. Although this law makes several important changes in the Federal water pollution control program, its most significant feature is its incorporation into the Act of several of the basic elements of the Settlement Agreement program for toxic pollution control. Sections 301(b)(2)(A) and 301(b)(2)(C) of the Act now require the achievement by July 1, 1984 of effluent limitations requiring application of BAT for "toxic" pollutants, including the 65 "priority" pollutants and classes of pollutants which Congress declared "toxic" under Section 307(a) of the Act. Likewise, EPA's programs for new source performance standards and pretreatment standards are now aimed principally at toxic pollutant controls. Moreover, to strengthen the toxics control program, Section 304(e) of the Act authorizes the Administrator to prescribe "best management practices" (BMPs) to prevent the release of toxic and hazardous pollutants from plant site runoff, spillage or leaks, sludge or waste disposal, and drainage from raw material storage associated with, or ancillary to, the manufacturing or treatment process.

In keeping with its emphasis on toxic pollutants, the Clean Water Act of 1977 also revises the control program for nontoxic pollutants. Instead of BAT for "conventional" pollutants identified under Section 304(a)(4) (including biochemical oxygen demand, oil and grease, suspended solids, fecal coliform and pH), the new Section 301(b)(2)(E) requires achievement by July 1, 1984, of "effluent limitations requiring the application of the best conventional pollutant control technology" (BCT). The factors considered in assessing BCT for an industry include the costs of attaining a reduction in effluents and the effluent reduction benefits derived compared to the costs and effluent reduction benefits from the discharge of publicly owned treatment works (Section 304(b)(4)(B)). For nontoxic, nonconventional pollutants, Sections 301(b)(2)(A) and (b)(2)(F) require achievement of BAT effluent limitations within three years after their establishment or July 1, 1984, whichever is later, but not later than July 1, 1987.

The purpose of this proposed regulation is to provide effluent limitations for BPT, BAT and BCT, and to establish NSPS, pretreatment standards for existing sources (PSES), and pretreatment standards for new sources (PSNS), under Sections 301,304,306,307 and 501 of the Clean Water Act.

B. Prior EPA Regulations

On June 28, 1974, EPA promulgated effluent limitations for BPT and BAT, new source performance standards, and pretreatment standards for new sources for basic steelmaking operations (Phase I) of the integrated steel industry, 39 FR 24114-24133, 40 CFR Part 420, Subparts A-L. That regulation covered 12 subcategories of the industry: By-Product Cokemaking, Beehive Cokemaking, Sintering, Blast Furnace (Iron), Blast Furnace (Ferromanganese), Basic Oxygen Furnace (Semi-Wet Air Pollution Control Methods), Basic Oxygen Furnace (Wet Air Pollution Control Methods), Open Hearth, Electric Arc Furnace (Semi-Wet Air Pollution Control Methods), Electric Arc Furnace (Wet Air Pollution Control Methods), Vacuum Degassing, and Continuous Casting and Pressure Slab Molding.

In response to several petitions for review, the United States Court of Appeals for the Third Circuit remanded that regulation on November 7, 1975, American Iron and Steel Institute, et al. v EPA, 526 F.2d 1027 (3rd Cir. 1975). While the Court rejected all technical challenges to the BPT limitations, it held that the BAT effluent limitations and NSPS for certain subcategories were "not demonstrated." In addition, the court questioned the entire regulation on the grounds that EPA had failed to consider adequately the impact of plant age on the cost or feasibility of retrofitting pollution controls, had failed to assess the impact of the regulations on water scarcity in arid and semi-arid regions of the country, and had failed to make adequate "net/gross" provisions for pollutants found in intake water supplies.[1]

On March 29, 1976, EPA promulgated BPT effluent limitations and proposed BAT limitations, NSPS standards and PSNS standards for steel forming and finishing operations (Phase II) within the steel industry, 39 FR 12990-13030, 40 CFR Part 420, Subparts M-Z. That regulation covered 14 subcategories of the industry: Hot Forming- Primary; Hot Forming-Section; Hot Forming-Flat; Pipe &

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[1] The court also held that the "form" of the regulations was improper, because they did not provide "ranges" of limitations to be selected by permit issuers. This holding, however, was recalled in American Iron and Steel Institute, et al. v EPA, (3d Cir.1977).

Tube; Pickling- Sulfuric Acid-Batch & Continuous; Pickling-Hydrochloric Acid-Batch & Continuous; Cold Rolling; Hot Coatings-Galvanizing; Hot Coatings- Terne; Miscellaneous Runoffs-Storage Piles, Casting, and Slagging; Combination Acid Pickling-Batch and Continuous; Scale Removal-Kolene and Hydride; Wire Pickling and Coating, and Continuous Alkaline Cleaning.

The U.S. Court of Appeals for the Third Circuit remanded that regulation on September 14, 1977, American Iron and Steel Institute, et al. v EPA, 568 F.2d 284 (3d Cir. 1977). While the court again rejected all technical challenges to the BPT limitations, it again questioned the regulation in regard to the age/retrofit and water scarcity issues. In addition, the court invalidated the regulation for lack of proper notice to the specialty steel industry, and directed EPA to reevaluate its cost estimates in light of "site-specific costs" and to reexamine its economic impact analysis.[2]

On June 26, 1978 the Agency promulgated General Pretreatment Regulations applicable to existing and new indirect dischargers within the steel industry and other major industries, 43 FR 27936-27773 40 CFR Part 403. Those regulations are currently in effect.

C. Overview of the Industry

The manufacture of steel involves many processes which require large quantities of raw materials and other resources. Steel facilities range from comparatively small plants engaging in one or more production processes to extremely large integrated complexes engaging in several or all production processes. Even the smallest steel facility, however, represents a fairly large industrial complex. Because of the wide variety of products and processes, operations vary from plant to plant. Table II-1 lists the various products classified by the Bureau of the Census under Major Group 33 - Primary Metal Industries.

The steel industry can be segregated into two major components - raw steelmaking and forming and finishing operations. EPA estimates that there are about 680 plant locations containing over 2000 individual steelmaking and forming and finishing operations. A listing of these plants is presented in Appendix B to this volume. Table II-2 is an inventory of production operations by subcategory.

In the first major process, coal is converted to coke which is then combined with iron ore and limestone in a blast furnace to produce iron. The iron is then purified into steel in either open hearth, basic oxygen, or electric arc furnaces. Finally,

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[2] The court also held that EPA had no statutory authority to exempt plants in the Mahoning Valley region of Eastern Ohio from compliance with the BPT limitations.

the steel can be further refined by vacuum degassing. Following these steelmaking operations the steel is subjected to a variety of hot and cold forming and finishing operations. These operations produce products of various shapes and sizes, and imparts desired mechanical and surface characteristics. Figure II-1 is a process flow diagram of the steelmaking segment of the industry.

Coke plants are operated at integrated facilities to supply coke for the production of iron in blast furnaces. Nearly all active coke plants are by-product plants which produce, in addition to coke, such usable by-products as coke oven gas, coal tar, crude or refined light oils, ammonium sulfate or anhydrous ammonia, and napthalene. A by-product coke plant consists essentially of ovens in which bituminous coal is heated, in the absence of air, to drive off volatile components. The coke remaining as residue in the ovens is supplied to the blast furnaces, while the volatile components are recovered and processed into materials of potential value in the by-products recovery processes. Less than one percent of domestic coke is produced in beehive cokemaking processes.

The coke from by-product cokemaking and beehive cokemaking is then supplied to blast furnace processes where molten iron is produced for subsequent steelmaking. In blast furnaces, iron ore, limestone and coke are placed into the top of the furnace and heated air is blown into the bottom. Combustion of the coke provides heat, which produces metallurgical reactions. The limestone forms a fluid slag which combines with unwanted impurities in the ore. Two kkg (2.2 tons) of ore, 0.54 kkg (0.6 tons) of coke, 0.45 kkg (0.5 tons) of limestone, and 3.2 kkg (3.5 tons) of air produce approximately 0.9 kkg (1 ton) of iron, 0.45 kkg (0.5 tons) of slag, and 4.5 kkg (5 tons) of blast furnace gas containing the fines (flue dust) carried out by the blast. Molten iron from the bottom of the furnace and molten slag, which floats on top of the iron, are periodically withdrawn. Blast furnace flue gas, which has considerable heating value, is cleaned and then burned in stoves to preheat the incoming air blast to the furnace.

Steel is an alloy of iron containing less than 1.0% carbon. The basic raw materials for steelmaking are hot metal or pig iron, steel scrap, limestone, burned lime, dolomite, fluorspar, iron ores, and iron-bearing materials such as pellets or mill scale. Steelmaking consists essentially of oxidizing constituents (particularly carbon) to specified low levels, and then adding various alloying elements according to the grade of steel to be produced.

The principal steelmaking processes in use today are the Basic Oxygen Furnace (BOF or BOP), the Open Hearth Furnace, and the Electric Arc Furnace. These processes refine the product of the blast furnace (hot metal or, if cooled, pig iron) which contains approximately 6% carbon. The charge to steelmaking operations consists of blast furnace hot metal, scrap, or both, and may include alloying elements to produce various types of steel.

Although declining in recent years, 16% of the steel produced in the United States is made in open hearth furnaces. Open hearth furnaces, while similar in design, may vary widely in tonnage capacity. Furnaces in this country range in capacity from 9 to 545 kkg (10 to 600 tons) per heat. The steelmaking ingredients are charged into the front of the furnace through movable doors, while the flame to refine the steel is supplied by liquid or gaseous fuel ignited by hot air.

In the standard open hearth furnace, molten steel is tapped from the furnace eight to ten hours after the first charge. Many furnaces use oxygen lances which create more intense heat to reduce tap-to-tap time. The tap-to-tap time for the oxygen-lanced open hearth averages about eight hours. The average is about ten hours when oxygen is not used. The open hearth furnace allows the operator, in effect, to "cook" the steel to required specifications. The nature of the furnace permits the operator to continually sample the contents and make necessary additions. The major drawback of the process is the long time required to produce a "heat."

Since the introduction in the United States of the more productive basic oxygen process, open hearth production has declined from a peak of 93 million kkg (102 million tons) in 1956 to 19 million kkg (21 million tons) in 1978. Most basic oxygen furnaces can produce eight times the amount of steel produced by a comparable open hearth furnace during the same production time. The annual domestic production of steel by the basic oxygen process has increased from about 545,000 kkg (600,000 tons) in 1957 to 75 million kkg (83 million tons) in 1978.

Vessels for the basic oxygen process generally are vertical cylinders surmounted by a truncated cone. Scrap and molten iron are lowered into the vessel and oxygen is then admitted. High-purity oxygen is supplied at high pressure through a water-cooled tube mounted above the center of the vessel. A violent reaction occurs immediately, bringing the molten metal and hot gases into intimate contact causing impurities to burn off quickly. An oxygen blow of 18 to 22 minutes is normally sufficient to refine the metal. Finally, alloys are added and the steel is then tapped. A basic oxygen furnace can produce 180 to 270 kkg (200 to 300 tons) of steel per hour and permits very close control of steel quality. Another major advantage of the process is its ability to handle a wide range of raw materials. Scrap may be light or heavy, and the oxide charge may be iron ore, sinter, pellets, or mill scale.

Another process for making steel is the electric arc furnace. This process is uniquely adapted to the production of high quality steels. Practically all stainless steel is produced in electric arc furnaces. Electric furnaces range up to nine meters

(30 feet) in diameter and produce from 1.8 to 365 kkg (2 to 400 tons) per cycle in 1.5 to 5 hours.

The cycle in electric furnace steelmaking consists of a scrap charge, meltdown, a hot metal charge, a molten metal period, boil, a refining period, and the pour. The electric arc furnace generates heat by passing an electric current between electrodes through the charge in the furnace. The refining process is similar to that of the open hearth, but more precise control is possible in the electric furnace. Use of oxygen in the electric furnace has been common practice for many years.

Many mills operate only electric furnaces and use scrap as the raw material. In most "cold shops" the electric arc furnace is the sole steelmaking process. They are the principal steelmaking process employed by the so-called mini steel plants which have been built since World War II. The annual production of steel in the electric arc furnace has increased from about 7.2 million kkg (8 million tons) in 1957 to 29 million kkg (32 million tons) in 1978. Although electric arc furnaces are traditionally smaller in capacity than open hearth or basic oxygen furnaces, a trend toward furnaces with larger heating capacities has recently developed.

Following the steelmaking processes are the hot forming (including continuous casting) and cold finishing operations. These operations are so varied that simple classification and description is difficult. In general, hot forming primary mills reduce ingots to slabs or blooms and secondary hot forming mills reduce slabs or blooms to billets, plates, shapes, strip, and other forms. Steel finishing operations involve a number of other processes that do little to alter the dimensions of the hot rolled product, but which impart desirable surface or mechanical properties. The product flow of these operations is shown in Figures II-2 and II-3.

It is possible, and often economical, to roll ingots directly through the bloom, slab, or billet stages into more refined or finished steel products in one continuous mill, frequently without reheating. Large tonnages of standard rails, beams, and plates are produced regularly by this practice. Most of the ingot tonnage, however, is rolled into bloom, slabs, or billets in one mill, then cooled, stored, and eventually reheated and rolled in other mills or forged.

The basic operation in a primary mill is the gradual compression of the steel ingot between two rotating rolls. Multiple passes through the rolls, ususally in a reversing mill, are required to reshape the ingot into a slab, bloom, or billet. As the ingot begins to pass through the rolls, high pressure water jets remove surface scale. The ingot is passed back and forth between the horizontal and vertical rolls while manipulators turn the ingot. When the desired shape is achieved in the rolling operation, the end pieces (or crops) are removed by electric or hydraulic shears. The semi-finished pieces are stored or sent to reheating furnaces for subsequent rolling operations.

As the requirement for high quality steel increases, increasing attention is being devoted to the conditioning of semi-finished products. This conditioning involves the removal of surface defects from blooms, billets, and slabs prior to shaping. Defects such as rolled seams, light scabs, and checks generally retain their identity during subsequent forming processes and result in inferior products. Surface defects may be removed by manual chipping, machine chipping, scarfing, grinding, milling, and hot steel scarfing. The various mechanical means of surface preparation used are common in all metal working and machine shop operations. Scarfing is a process of supplying jet streams of oxygen to the surface of the steel product, while maintaining high surface temperatures, which results in rapid oxidation and localized melting of a thin layer of the metal. While the process may be manual (consisting of the continuous motion of an oxyacetylene torch along the length of the piece undergoing treatment) in recent years the hot scarfing machine has come into wide use. This machine is adapted to remove a thin layer (1/8 in. or less) of metal from the steel passed through the machine in a manner analogous to the motion through rolling mills.

Merchant-bar, rod, and wire mills are continuous operations which produce a wide variety of products, ranging from shapes of small size through bars and rods. The designations of the various mills as well as the classification of their products are not very well defined within the industry. In general, the small cross-sectional area and very long lengths distinguish the products of these mills. The raw materials for these mills are reheated billets. Some older mills use hand looping operations in which the material is manually passed from mill stand to mill stand. Newer mills use mechanical methods to transfer the material from stand to stand. As with other rolling operations, the billet is progressively compressed and shaped to the desired dimensions in a series of rolls. Water sprays are used throughout the operation to remove scale.

The continuous hot strip mill processes slabs which are brought to rolling temperatures in continuous reheating furnaces. The slabs then are passed through scale beakers and high pressure water sprays which dislodge loosened scale. A series of roughing stands and a rotary crop shear produce a section that can be finished into a coil of the proper weight and gauge. A second scale breaker and high pressure water sprays precede the finishing stands where final size reductions are made. Cooling water is applied by sprays on the runout table, and the finished strip is coiled. These mills can turn a 6 ft. thick slab of steel into a thin strip or sheet a quarter of a mile long in three minutes or less. The modern hot strip mill produces a product as wide as 96 in., although the most common width in newer mills is 80 in. Products of the hot strip mill are sold as produced, or are further processed in cold reduction mills. Cold rolled products are sold as produced or are used in producing plated or coated products.

Welded tubular products are made from hot-rolled skelp with square or slightly beveled edges. The width and thickness of the skelp is selected to suit the desired size and wall thicknesses. The coiled skelp is uncoiled, heated, and fed through forming and welding rolls where the edges are pressed together at high temperatures to form a weld. Welded pipe or tube can also be made by the electric weld processes, where the weld is made by either fusion or resistance welding. Seamless tubular products are made by rotary piercing of a solid round bar or billet, followed by various forming operations to produce the required size and wall thickness.

Correct surface preparation is the most important requirement for satisfactory application of protective coatings to steel. Without a properly cleaned surface, even the most expensive coatings will fail to adhere or prevent rusting of the steel base. A variety of cleaning methods are used to insure proper surface preparation for subsequent coating. Also, the steel surface must be cleaned at various production stages to insure that the oxides which form on the surface are not worked into the finished product causing marring, staining, or other surface imperfections.

The pickling process chemically removes oxides and scale from the surface of the steel by the action of water solutions of inorganic acids. While pickling is only one of several methods of removing undesirable surface oxides, this method is the most widely used because of comparatively low operating costs and ease of operation.

Some products such as tubes and wire are pickled in batch operations. The product is immersed in an acid solution until the scale or oxide film is removed. The material is lifted from the bath, allowed to drain, and then rinsed by sequential immersion in rinse tanks.

Pickling lines for hot-rolled strip operate continuously on coils that are welded together. The steel passes through the pickler countercurrent to the flow of the acid solution, and is then sheared and recoiled. Most carbon steel is pickled with sulfuric or hydrochloric acid; stainless steels are pickled with hydrochloric, nitric, and hydrofluoric acids. Various organic chemicals are used in the pickling process to inhibit acid attack on the base metal, while permitting preferential attack on the oxides. Wetting agents are used to improve the effective contact of the acid solution with the metal surface. As in the batch operation, the steel passes from the pickling bath through a series of rinse tanks.

Alkaline cleaners are used where necessary to remove mineral and animal fats and oils from the steel surface. Caustic soda, soda ash, alkaline silicates, and phosphates are common alkaline cleaning agents. Merely dipping the steel in alkaline solutions of various compositions, concentrations, and temperatures is often satisfactory. The use of electrolytic cleaning may be employed for large scale production, or where a cleaner product is desired. Sometimes the addition of wetting agents to the cleaning bath facilitates cleaning.

Blast cleaning is a process which uses abrasives such as sand, steel, iron grit, or shot to clean the steel. The abrasives come into contact with the steel by either a compressed air blast cleaning apparatus or by rotary type blasting cleaning machines. However, these methods usually result in a roughened surface. The degree of roughness must be regulated to insure that the product is satisfactory for its intended use. Newer methods of blast cleaning produce smooth finishes and, consequently have potential as substitues for some types of pickling.

Steel finishing also includes operations such as cold rolling, cold reduction, cold drawing, tin plating, galvanizing, coating with other metals, coating with organic compounds as well as inorganic compounds, and tempering.

Cold reduced flat rolled products are made by cold rolling pickled strip steel. The thickness of the steel is reduced by 25% to 99% in this operation to produce a smooth, dense surface. The product may be sold as cold reduced, but is usually heat treated.

The cold reduction process generates heat that is dissipated by flooded lubrication systems. These systems use palm oil or synthetic oils which are emulsified in water and directed in jets against the rolls and the steel surface during rolling. The cold reduced strip is then cleaned with alkaline detergent solutions to remove the rolling oils prior to coating operations.

Tin plate is made from cleaned and pickled cold reduced strip by either the electrolytic or hot dip process. The hot dip process consists of passing the steel through a light pickling solution; a tin pot containing a flux and the molten tin; and a bath of palm oil. Effluent limitations for discharges from the electrolytic processes are not included herein but are addressed in the Development Document for the Electroplating Point Source Category (40 CFR 413).

Hot dipped galvanized sheets are produced on either batch or continuous lines. The process consists essentially of a light pickling in hydrochloric acid and the application of the zinc coating by dipping in a pot containing molten zinc. Variations in continuous hot dip operations include alkaline cleaning, continuous annealing in controlled atmosphere furnaces, and a variety of fluxing techniques.

In recent years, steel products which are coated with various synthetic resins have become commercially important. Other steel products are being produced with coatings of various metals and inorganic materials. Several major tin plate manufacturers are currently substituting chromium plating for tin plating for container products. Finishing operations for stainless steel products requiring a bright finish consists of rolling on temper mills or mechanical polishing.

A more detailed description of steel industry operations can be found in the individual subcategory reports of this Development Document, and in the references cited in Section XIV.

D. Summary of EPA Guidelines Development Methodology and Overview

Approach to the Study

In order to develop the proposed effluent limitations and standards, EPA first studied the steel industry to determine whether differences in raw materials, final products, manufacturing processes, equipment, age and size of plants, water usage, wastewater constituents, or other factors justified the development of separate effluent limitations and standards for different segments of the industry. This study included the identification of raw waste and treated effluent characteristics, including: (1) the sources and volume of water used, the processes employed, and the sources of pollutants and wastewaters in the plant, and (2) the constituents of wastewaters, including toxic pollutants. EPA then identified the constituents of wastewaters which should be considered for effluent limitations and standards.

Next, EPA identified several distinct control and treatment technologies, including both in-plant and end-of-process technologies, which are in use or capable of being used in the steel industry. The Agency compiled and analyzed historical data and newly generated effluent quality data resulting from the application of these technologies. Long term performance, operational limitations, and reliability of each treatment and control technologies were also identified where possible. In addition, EPA considered the nonwater quality environmental impacts of these technologies, including impacts on air quality, solid waste generation, water consumption, and energy requirements.

The Agency then developed the costs of each control and treatment technology by using standard engineering cost analyses as applied to steel industry wastewater characteristics. EPA then derived unit process costs from model plant characteristics (production and flow) applied to each treatment process unit (i.e., primary coagulation-sedimentation, activated sludge, multi-media filtration). These unit process costs were added to yield total cost at each treatment level. After confirming the reasonableness of this methodology by comparing EPA cost estimates to treatment system costs supplied by the industry and other data, the Agency evaluated the economic impacts of these costs. (Costs are discussed in detail in each subcategory report and the economic impact on the industry is reviewed in the economic impact analysis done for this study.)

Upon consideration of these factors, as more fully described below, EPA identified various control and treatment technologies as models for the BPT, BCT, BAT, PSES, PSNS, and NSPS limitations and standards. The proposed regulation, however, does not require the installation of any particular technology. Rather, it requires the achievement of effluent limitations representative of the proper operation of these technologies, equivalent technologies, or operating practices.

The effluent limitations and standards for BPT, BCT, BAT, PSES, PSNS and NSPS are expressed as mass limitation (lbs/1000 lbs of product) and were calculated by multiplying three figures: (1) effluent concentrations determined from analysis of control technology performance data, (2) wastewater flow for each subcategory, and (3) an appropriate conversion factor. EPA performed the basic calculation for each limited pollutant for each subcategory of the industry.

Data and Information Gathering Program

Upon initiating this study, EPA reviewed the data underlying its previous studies of the steel industry.[3] The Agency concluded that additional data were required to respond to the Third Circuit's remands and to develop limitations and standards in accordance with the Settlement Agreement and the Clean Water Act of 1977.

The Agency sent Data Collection Portfolios (DCPs) to all basic steelmaking operations and to at least 85% of the steel forming and finishing operations in the United States. The DCPs requested information concerning production processes, production capacity and rates, process water usage, wastewater generation rates, wastewater treatment and disposal methods, treatment costs, location, age of production and treatment facilities, as well as general analytical information. The Agency received responses from 388 steelmaking operations and from 1544 steel forming and finishing operations.

The Agency also sent Detailed Data Collection Portfolios (D-DCPs), under the authority of Section 308 of the Act, to 50 steelmaking facilities and 128 forming and finishing facilities.

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[3] See EPA 440/1-74-024a; Development Document for Effluent Limitation Guidelines and New Source Performance Standards for the Steel Making Segment of the Iron and Steel Manufacturing Point Source Category, June 1974; and EPA 440/1-76/048-d; Development Document for Interim Final Effluent Limitations Guidelines and Proposed New Source Performance Standards for the Forming, Finishing and Specialty Steel Segments of the Iron and Steel Manufacturing Point Source Category; March, 1976.

The D-DCPs requested detailed information concerning the cost of installing pollution control equipment including capital, annual and retrofit costs. The D-DCPs also requested long-term analytical data and data regarding specific production operations.

The Agency determined the presence and magnitude of the 129 specific toxic pollutants in iron and steel manufacturing wastewaters in a two-part sampling and analysis program involving 31 steelmaking facilities and 83 forming and finishing facilities. Table II-3 is a listing of facilities sampled for this study. Table II-4 is a summary of the number of sampled plants and facilities responding to EPA questionnaires.

The primary objective of the field sampling program was to obtain composite samples of wastewater from which to determine the concentrations of toxic pollutants. Sampling visits were made during two or three consecutive days of plant operation, with raw wastewater samples taken either before treatment or after minimal preliminary treatment. Treated effluent samples were taken following application of in-place treatment technologies. EPA also sampled intake water to determine the presence of toxic pollutants prior to contamination by steelmaking processes.

This first phase of the sampling program detected and quantified wastewater constituents included on the list of 129 toxic pollutants. Wherever possible, each sample of an individual raw wastewater stream, a combined waste stream, or a treated effluent was collected by an automatic, time series compositor over three 24-hour sampling periods. Where automatic compositing was not possible, grab samples were taken and composited manually. The purpose of the second phase of the sampling program was to confirm the presence and further quantify the concentrations and waste loadings of the toxic pollutants found during the first phase of the program.

EPA used the analytical techniques described in Sampling and Analysis Procedures for Screening of Industrial Effluents for Priority Pollutants, revised April, 1977. Significant quantities of organic priority pollutants were found in wastewaters from Cokemaking and Cold Rolling.

Metals analysis was performed by AA spectrophotometry. However, the standard cold vapor method was used for mercury. This 304(h) method was modified in order to avoid excessive matrix interference that caused high limits of detection.

Analyses for total cyanide and cyanide amenable to chlorination were also performed using 304(h) methods.

Analysis for asbestos fibers used transmission electron microscopy with selected area difraction; results were reported as chrysotile fiber count.

Analyses for conventional pollutants (BOD5, TSS, pH, and oil and grease) and nonconventional pollutants (total residual chlorine, iron, ammonia, fluoride, and COD) were performed using 304(h) methods.

Industry Subcategorization

The Agency has adopted a revised subcategorization of the steel industry to more accurately reflect production operations in the industry and to simplify the implementation of the regulation. The modified subcategorization is displayed in Table II-5. Table II-6 cross references the modified categorization with subparts of the previous regulations. Additions and deletions to the subcategories and their subdivisions are described below.

1. Blast Furnace-Ferromanganese

   The Agency has concluded that its original subcategorization of blast furnace operations into ironmaking and ferromanganese furnaces is not required beyond the BPT level. BPT limitations for ferromanganese furnaces are different from those for ironmaking blast furnaces and are being reproposed. Since there are no ferromanganese blast furnaces in operation and most ferroalloy production is by "submerged" electric furnaces, the Agency has concluded that BAT, BCT, NSPS, PSES, and PSNS limitations and standards for ferromanganese blast furnaces are not necessary. Should any ironmaking blast furnaces convert to ferromanganese production, those limitations should be developed on a case-by-case basis employing "best professional judgment" and the respective technologies contained herein.

2. BOF-WET

   Based upon its review of BOF air cleaning systems pursuant to the Court's remand, the Agency concluded that the BOF wet air cleaning subidivison should be further divided into "open combustion" and "suppressed combustion" due to differences in applied and discharge flow rates.

3. Open Hearth

   A semi-wet segment was added to reflect the use of semi-wet air pollution systems in the open hearth category.

4. Hot Forming-Primary

   Based upon a review of specialty hot forming operations and the respective applied flow rates, the specialty segment was divided into operations with scarfing and those without scarfing.

5. Hot Forming - Section

The Agency further divided this operation into carbon and specialty operations to take into account their different applied flow rates.

6. Sulfuric Acid Pickling

Based on its review of the data base for this subcategory, the Agency has added a batch neutralization segment. Several examples of batch neutralization sulfuric acid pickling plants were found.

7. Hydrochloric Acid Pickling

The Agency further divided this operation into batch and continuous operations to take into account different applied flow rates.

8. Combination Acid Pickling

The original subcategorization of this process provided for different limitations for batch-pipe and tube and batch-other lines. Based on the additional data, the Agency has concluded that only one set of limitations is appropriate for all batch operations.

9. Cold Forming

Cold worked pipe and tube operations have been separated from the hot worked pipe and tube operations in this proposed regulation. In addition, the cold worked pipe and tube segment has been divided into operations that use water and those that use oil solutions.

10. Alkaline Cleaning

No changes were made to this subcategory.

11. Hot Coatings

Two changes have been made to the hot coating subcategory. First, the galvanizing segment has been modified to take into account differences in applied flows between strip, sheet and miscellaneous product operations, and those operations that produce wire products and fasteners. Also, an additional segment (Other Metal Coatings) has been added to cover hot coating operations other than galvanizing and terne coating.

As noted later in the development document, the prior BPT limitations were modified only where they could not be supported. The revised subcategorization is applicable to each group of effluent limitations and standards proposed herein (BPT, BAT, NSPS, PSES and PSNS).

Regulated Pollutants

The basis upon which EPA selected the pollutants to be specifically limited, as well as the general nature and environmental effects of these pollutants is set out in Section V.

A. BPT

The pollutants limited by this proposed regulation include, for the most part, the same pollutants limited by the remanded BPT regulations. Some pollutants have been deleted from the list of limited pollutants (e.g., chromium for hydride scale removal operations) because the sampling conducted subsequent to the promulgation of the prior regulations showed that only very low levels of these pollutants existed in the process wastewaters. In no subcategories were additional pollutants proposed for limitation at BPT. The discharge of BPT pollutants is controlled by maximum monthly average and maximum daily mass effluent limitations in kilograms per 1000 kilograms (lbs/1000 lbs) of product, which are calculated by multiplying demonstrated effluent concentrations, model flows for each subcategory, and appropriate conversion factors.

B. BCT

The pollutants controlled by this regulation include conventional pollutants, TSS, oil and grease, and pH. BCT limitations are being proposed in all twelve steel industry subcategories. Where the BCT technologies failed to control conventional pollutants at less cost than could be accomplished in POTWs, the proposed BCT limitations are set at the BPT level.

C. BAT and NSPS

1. Nontoxic, Nonconventional Pollutants

The nontoxic, nonconventional pollutants limited by BAT and NSPS include ammonia-n and fluoride. These pollutants are subject to numerical limitations expressed in kilograms per 1000 kilograms (lbs/1000 lbs) of product.

2. Toxic Pollutants

Forty-eight toxic pollutants were found at concentrations above treatability levels in steel industry wastewaters. (Section V contains a list of these pollutants.) Most of the toxic pollutants (29) are found in the cokemaking subcategory. The Agency is proposing effluent limitations for the following toxic pollutants: total cyanide, benzene, naphthalene, benzo(a)pyrene, 1,1,1-trichloroethane, 2-nitrophenol, anthracene, tetrachloro- ethylene, cadmium, chromium, copper, lead, nickel, and zinc. These pollutants are subject to numerical limitations expressed in kilograms per 1000 kilograms (lbs/1000 lbs) of product. The remaining toxic pollutants found in steel industry wastewaters, which are not specifically limited, will be controlled by limitations established for "indicator" pollutants discussed below.

3. Indicator Pollutants

The cost of analyses for the many toxic pollutants found in steel industry wastewaters has prompted EPA to propose an alternative method of regulating certain toxic pollutants. Instead of proposing specific effluent limitations for each of the forty-eight toxic pollutants found in steel industry waste- waters at significant levels, the Agency is proposing effluent limitations for certain "indicator" pollutants. These include chromium, lead, zinc, phenol and certain other toxic organic pollutants. The data available to EPA generally show that the control of those "indicator" pollutants will result in comparable control of toxic pollutants not specifically limited. By establishing specific limitations for only the "indicator" pollutants, the Agency has reduced the high cost and delays of monitoring and analyses that would result from limitations for each toxic pollutant. Industry will be required to spend $8.9 million annually for monitoring the "indicator" pollutants compared to $17.1 million which would be required if it were to monitor for all toxic pollutants in its wastewaters. The pollutants found and those that have been specifically limited at the BAT and NSPS levels of treatment are listed in Section V. The bases for selection of "indicator" pollutants is presented in Section X of each subcategory report.

D. PSES and PSNS

The pollutants for which PSES and PSNS have been proposed are identical to those limited at BAT and NSPS, with the exception of the conventional pollutants. Limitations are being proposed for certain toxic pollutants, and other "indicator" pollutants to insure against POTW upsets, to prevent accumulation of toxic pollutants in POTW sludges, and to guard against pass-through of certain toxic pollutants. The PSES and PSNS are expressed as maximum monthly average and maximum daily mass limitations in kilograms per 1000 kilograms (lbs/1000 lbs) of product.

Control and Treatment Technology

A. Status of In-Place Technology

There are many different treatment technologies currently employed in the steel industry. Generally, primary wastewater treatment systems rely upon physical/chemical methods including neutralization, sedimentation, flocculation and filtration. Treatment for toxic pollutants includes advanced technologies such as biological oxidation, carbon adsorption, ion exchange, ultrafiltration, multiple-effect evaporation, reverse osmosis, and more sophisticated chemical techniques.

Within the cokemaking subcategory, treatment systems must include a component to remove organic wastes. Organic removal steps include biological methods such as bio-oxidation lagoons and activated sludge plants and physical/chemical methods such as ammonia stills, dephenolizers and activated carbon systems. Sedimentation and filtration techniques are employed as well in this subcategory.

Treatment facilities at plants in the ironmaking and steelmaking subcategories rely heavily upon sedimentation and flocculation techniques followed by recycle of treated wastewaters. Wastewaters from nearly all hot forming operations are treated in scale pits followed by lagoons, clarifiers, filters, or combinations thereof with recycle of treated or partially treated wastewaters. Coagulants such as lime, alum, and ferric sulfate are normally used in conjunction with clarifiers. Filters are usually of the multi-media pressure type.

Cold finishing treatment techniques include equalization prior to further treatment, neutralization with lime, caustic or acid, flocculation with polymer and sedimentation. Central or combined treatment practices are employed widely with these operations.

The use of recycle is a common practice throughout the steel industry. Recycle of treated process wastewater can be effectively used as a means of significantly reducing discharge loadings to receiving streams. Systems employing a high rate of recycle are demonstrated in several subcategories. Recycle may be applied to specific sources such as barometric condensers (coke) or fume scrubbers (pickling) or to the total effluent of a treatment facility.

B. Advanced Technologies Considered

The Agency has considered advanced treatment systems to control the level of toxic and conventional pollutants at the BAT, NSPS, PSES, and PSNS levels of treatment. Some of these include in-plant control, however, most involve the installation of additional treatment components.

In-plant control has been demonstrated in several subcategories and as a result these are being incorporated into the treatment models at the BAT, BCT, NSPS, PSES, and PSNS levels. Cascade rinsing is a means to reduce wastewater volumes. This technology significantly reduces the volume of wastewaters requiring treatment.

Other in-plant control measures have been considered such as reduction of wastewater generation by process water reduction and recycle and process modifications. These control measures are highly subcategory specific and are discussed in detail in the respective subcategory reports.

Add-on technology to BPT level technology is also the basis for the BAT, BCT, NSPS, PSES, and PSNS levels of treatment. Some of these control measures for toxic pollutants include 2-stage or extended biological treatment (cokemaking); granular activated carbon; powdered carbon addition; pressure filtration; pressure filtration accompanied with sulfide addition; and, multi-stage evaporation/condensation systems. Details on these advanced systems are presented in Section VI.

Capital and Annual Cost Estimates

Additional expenditures will be required by the steel industry to achieve compliance with the proposed limitations. A short discussion of the in-place and required capital costs and annual costs are presented below for each level of treatment, based upon the size and status of the industry as of January 1, 1978. All costs are presented in July 1, 1978 dollars.

A. BPT

EPA estimates that as of January 1, 1978, the steel industry had expended about $1.5 billion towards compliance with BPT limitations out of a total required cost of $2.3 billion. Industry will incur annualized costs (including interest, depreciation, operating and maintenance) of about $300 million when BPT has been fully implemented.

Compliance with the proposed BPT effluent limitations will result in the removal of about 45,000 tons per year of toxic organic pollutants, 137,000 tons per year of toxic inorganic pollutants and 14,500,000 tons per year of other pollutants from raw wastewaters. EPA believes that these effluent reduction benefits justify the associated costs, and other environmental impacts which are minor in relation to these benefits.

B. BAT and BCT

EPA estimates that as of January 1, 1978, compliance with the proposed BAT and BCT limitations may require the steel industry to invest about $600 million in addition to the proposed BPT investment and the money already spent on BAT systems. The annualized costs for the steel industry, in addition to the proposed BPT costs, may equal a total of about $150 million (representing about a 0.4 percent increase in steel prices).

Compliance with the proposed BAT and BCT effluent limitations will result in the removal of about 1900 tons per year of toxic organic pollutants, 2500 tons per year of toxic inorganic pollutants and 130,000 tons per year of other pollutants. The Agency believes that the costs of compliance with the proposed BAT and BCT limitations and other environmental impacts are reasonable and acceptable in light of the effluent reduction benefits obtained.

Basis for Effluent Limitations and Standards

As noted briefly above, the effluent limitations and standards for BPT, BAT, BCT, NSPS, PSES, and PSNS are expressed as mass limitations in kilograms per 1000 kilograms (lbs/1000 lbs) of product. The mass limitation is derived by multiplying an effluent concentration (determined from the analysis of treatment component performance) by a model flow appropriate for each subcategory on a gallons/ton basis. Conversion factors are applied to yield the appropriate kg/kkg (lbs/1000 lbs) value for each limited pollutant. The limitations neither require the installation of any specific control technology nor the attainment of any specific flow rate or effluent concentration. Various treatment alternatives or water conservation practices can be employed to achieve a particular effluent limitation. The model treatment systems presented in the development document provide one means to achieve the proposed limitations. In many cases, other technologies or operating practices are available to achieve the proposed limitations and standards.

Since the limitations are expressed in terms of mass (kg/kkg or lbs/1000 lbs), NPDES permits should be based on mass limitations. In order to convert the effluent limitations from kg/kkg (lbs/1000 lbs) to a load allocation, a tonnage value of either kkg/day or 1000 lbs/day is used. The tonnage values previously used for NPDES permitting have been the highest tonnage produced per month in the last five years, converted to a daily value.

Suggested Monitoring Program

The suggested long term monitoring and analysis program includes continuous flow monitoring, grab sampling for pH and oil and grease (3 grabs/day, once/week) and the collection of 24-hour composite samples once per week for all other pollutants. The composite samples would be analyzed for those pollutants regulated at the BPT, BAT and BCT treatment levels for each contributing subcategory. Due to the high cost of organic analysis ($750-$1000 per sample), monthly monitoring of limited organics in the cokemaking and cold forming subcategories is suggested.

More intensive monitoring is suggested for the period of time necesssary to determine initial compliance with the proposed limitations. Accordingly, as of July 1, 1984, (the compliance date for BAT and BCT), monitoring and analysis should be carried out on a schedule of five daily composites per week (once per week for GC/MS pollutants). When the appropriate regulatory authority determines that compliance has been demonstrated, monitoring can then be decreased to the frequencies indicated in the long term program discussed above.

Although total suspended solids and pH analysis are regulated for each subcategory, the total number of monitored pollutants ranges from three (alkaline cleaning) to ten (cold rolling - recirculation and direct application). The type of analysis influences the overall cost with organic analysis being the most expensive, and pH and the metals analyses being the least expensive.

Updated cost estimates were developed using three alternative contractural arrangements (in-house laboratory, contract laboratory, and C.W. Rice Laboratory), to obtain an estimate of the range of monitoring costs and to demonstrate that the monitoring program is feasible with the resources available to the industry.

The subcategories with the largest annual monitoring expenses are the cokemaking ($17,000-$19,900) and cold forming - recirculation and direct application ($18,600-$21,800) segments. The need for the GC/MS organic analyses accounts largely for the high cost. The lowest annual monitoring costs occurs in the alkaline cleaning subcategory ($2,794-$3,369). Annual monitoring costs for the remaining subcategories are between $4,000-$7,000.

The total annual monitoring cost to the industry is estimated to be approximately $6.0 to $8.9 million. However, actual expenses are likely to be less due to the preponderance of central treatment facilities in this industry. This substantially reduces the number of monitoring points compared to that required with completely separate treatment. Total BPT/BAT annual operating costs are estimated to be $450 million. The monitoring cost is roughly 1.3% to 2.0% of the annual costs of pollution control. The Agency considers these costs reasonable in light of the size and complexity of this industry.

Economic Impact on the Industry

The economic impact of the proposed regulation on the steel industry is fully described in Economic Analysis of Proposed Effluent Guidelines - Integrated Iron and Steel Industry.

Energy and Nonwater Quality Impacts

The elimination or reduction of one form of pollution may aggravate other environmental problems. Therefore, Sections 304(b) and 306 of the Act require EPA to consider the nonwater quality environmental impacts (including energy requirements) of certain regulations. In compliance with these provisions, EPA has considered the effect of this regulation on air pollution, solid waste generation, water scarcity, and energy consumption. There is no precise methodology for balancing pollution impacts against each other and against energy use. In proposing this regulation, EPA believes it is best serving often competing national goals with respect to environmental concerns and energy consumption.

The nonwater quality environmental impacts (including energy requirements) associated with the proposed regulation are described in general below and more specifically in the respective subcategory reports.

A. Air Pollution

Compliance with the proposed BPT, BAT, BCT, NSPS, PSES, and PSNS limitations and standards will not create any substantial air pollution problems. However, in several subcategories, slight air impacts may be expected. First, minimal amounts of volatile organic compounds may be released to the atmosphere by aeration in biological treatment in the cokemaking subcategory. Secondly, minor air emissions may result in the ironmaking subcategory when wastewaters are used to quench the hot slag generated in the process. And finally, water vapor containing some particulate matter will be released from the cooling tower systems used in several of the subcategories. None of these impacts are considered significant.

B. Solid Waste

EPA estimates that 37.3 million tons per year of solid waste (at 30% solids) will be generated by the industry when full compliance with BPT, BAT, BCT, and PSES is achived. Of this amount, nearly all (37.0 million tons) is generated in the BPT systems. This solid waste is comprised almost entirely of treatment plant sludges. Much larger quantities of other solid wastes are generated in the steel industry such as electric furnace dust and blast furnace slag; however, these and other solid wastes are not generated as a result of the water pollution control regulation being proposed. Process solid wastes (i.e., slag) are not included in this impact analysis.

The data gathered for this study demonstrate that most sludges are presently collected in the installed treatment systems. As a result, the industry is currently incurring disposal costs and finding necessary disposal sites. (It is unknown at this time how many of these disposal sites are secure, well maintained operations.) Also, the costs for disposal of these sludges are included in the Agency's present cost estimate. For these reasons, the incremental solid waste impacts associated with the proposed regulation are expected to be minimal.

C. Consumptive Water Loss

The question of water consumption in the steel industry as a result of the installation of wastewater treatment systems is a remand issue of the proposed 1974 and 1976 regulations dealt with in Section III. In summary, the Agency concludes the water consumed as a result of compliance with the proposed limitations is justified on both a national level and on a "water-scarce" regional level when compared to the effluent reduction benefits.

D. Energy Requirements

EPA estimates that the compliance with the proposed effluent limitations will result in the following consumption of electrical energy at the BPT and BAT/BCT levels of treatment:

Treatment Level	Net Energy Consumption (kw-hr)
BPT	1.20 billion
BAT/BCT/PSES	0.87 billion
Total	2.07 billion

This represents 3.6% of the total 57 billion kw-hrs of electrical energy consumed by the steel industry in 1978, or about 0.6% of the total energy consumed by the industry.

TABLE II-1

STANDARD INDUSTRIAL CLASSIFICATION AND APPLICABLE REGULATION LISTING IRON & STEEL MANUFACTURING

SIC	Code Name/Product Item
3312	**Blast Furnaces**
3312.01	Armor plate, rolled
3312.02	Axles, rolled
3312.03	Bars, iron rolled
3312.04	Bars, steel rolled
3312.05	Beehive coke products
3312.06	Billets, steel
3312.07	Blackplate
3312.08	Blast furnace prod.
3312.09	Blooms
3312.10	Car wheels, rolled
3312.11	Chem. rec. coke
3312.12	Coal Gas - coke
3312.13	Coal tar crudes
3312.14	Coke, beehive
3312.15	Chem. coke products
3312.16	Cold strip steel
3312.17	Distillates
3312.18	Fence posts, rolled
3312.19	Ferroalloys, BF (FeMn only)
3312.20	Flats, rolled
3312.21	Forgings
3312.22	Frogs
3312.23	Galvanized products
3312.24	Gun forgings
3312.25	Hoops, hot gal., rolled
3312.26	Hoops, hot rolled
3312.27	Hot rolled, iron & steel
3312.28	Ingots, steel
3312.29	Iron, pig
3312.30	Iron sinter
3312.31	Nut rods, rolled
3322.32	Pipe
3312.33	Plates, rolled
3312.34	Rail joints etc., rolled
3312.35	Railroad crossings

SIC	Code Name/Product Item
3312	Blast Furnaces
3312.36	Rails, iron and steel
3312.37	Rails, rerolled or renewed
3312.38	Rods, rolled
3312.39	Rounds, tube
3312.40	Sheet pilings, rolled
3312.41	Sheets, rolled
3312.42	Shell slugs, rolled
3312.43	Skelp
3312.44	Slabs, steel
3312.45	Spiegeleisen
3312.46	Spike rods, rolled
3312.47	Sponge iron
3312.48	Stainless steel
3312.49	Steel works
3312.50	Strips, galvanized
3312.51	Strips, iron & steel
3312.52	Structural shapes
3312.53	Tar
3312.54	Terneplate
3312.55	Ternes
3312.56	Tie plates
3312.57	Tin free steel
3312.58	Tin plate
3312.59	Tool steel
3312.60	Tube rounds
3312.61	Tubes, iron & steel
3312.62	Tubing, seamless
3312.63	Well casings
3312.64	Wheels
3312.65	Wire products
3312.66	Wrought pipe, tubing
3313	Electrometallurgical Products
3313.01	Additive alloys not BF
3313.02	Electromet. ex. Al, Mg & Cu
3313.03	Ferroalloys not in BF
3313.04	Ferrochromium
3313.05	Ferromanganese
3313.06	Ferromolybdenum
3313.07	Ferrophosphorus

TABLE II-1
STANDARD INDUSTRIAL CLASSIFICATION AND
APPLICABLE REGULATION LISTING
IRON & STEEL MANUFACTURING
PAGE 3

SIC	Code Name/Product Item
3313	Electrometallurgical Products
3313.08	Ferrosilicon not in BF
3313.09	Ferrotitanium
3313.10	Ferrotungsten
3313.11	Ferrovanadium
3313.12	High & ferroalloys not BF
3313.13	Manganese metal not BF
3313.14	Molybdenum silicon
3313.15	Nonferrous alloys
3313.16	Steel, electromet.
3315	Steel Wire Drawing & Steel Nails & Spikes
3315.01	Brads, steel
3315.02	Cable, steel
3315.03	Horseshoe nails
3315.04	Spikes, steel
3315.05	Staples, steel
3315.06	Tacks, steel
3315.07	Wire, ferrous
3315.08	Wire products, ferrous
3315.09	Wire, steel
3316	Cold Rolled Steel Sheet, Strip, and Bars
3316.01	Cold finished bars
3316.02	Cold rolled strip
3316.03	Corrugating CR
3316.04	Flat bright CR
3316.05	Razor blade strip CR
3316.06	Sheet steel CR
3316.07	Wire, flat
3317	Steel Pipe and Tubes
3317.01	Boiler tubes
3317.02	Conduit
3317.03	Pipe, seamless
3317.04	Pipe, wrought
3317.05	Tubes, seamless
3317.06	Tubing, mechanical
3317.07	Well casing
3317.08	Wrought pipe & tubes

SIC	Code Name/Product Item
3479	Coating, Engraving, and Allied Services, NEC
3479.01	Bonderizing
3479.02	Chasing
3479.03	Coating steel pipe
3479.04	Coating (hot dipping)
3479.05	Coating, plastic
3479.06	Coating, silicon
3479.07	Coating, rust prev.
3479.08	Dipping in plastic
3479.09	Enameling, porcelain
3479.10	Engraving jewelry
3479.11	Etching
3479.12	Galvanizing
3479.13	Japanning
3479.14	Jewelry enameling
3479.15	Lacquering
3479.16	Name plates
3479.17	Painting of metals
3479.18	Pan glazing
3479.19	Parkerizing
3479.20	Retinning
3479.21	Rust proofing
3479.22	Sherardizing
3479.23	Varnishing

TABLE II-2

SUBCATEGORY INVENTORY

Subcategory	No. of Plant Sites	No. of Individual Units(1)	No. of Units Direct Discharging	No. of Units Discharging to POTWs	No. of Units With Zero Discharges
A. Cokemaking					
1. By-Product	59	64	31	21	12(2)
2. Beehive	1	2	0	0	2
B. Sintering	21	21	16	1	4
C. Ironmaking	55	164	144	3	17
D. Steelmaking					
1. BOF					
a. Wet-Open Combustion	14	15(35)	14	0	1
b. Wet-Suppressed Combustion	6	6(15)	5	1	0
c. Semi-wet	10	10(20)	8	1	1
2. Open Hearth					
a. Wet	4	4(22)	4	0	0
b. Semi-wet	1	1(7)	1	0	0
3. Electric Arc Furnace					
a. Wet	8	9(17)	8	0	1
b. Semi-wet	3	3(8)	2	0	1
E. Vacuum Degassing	34	38	35	0	3
F. Continuous Casting	50	59	40	5	14

TABLE II-2
SUBCATEGORY INVENTORY
PAGE 2

Subcategory	No. of Plant Sites	No. of Individual Units(1)	No. of Units Direct Discharging	No. of Units Discharging to POTWs	No. of Units With Zero Discharges
G. Hot Forming					
1. Primary	81	111	101	7	3
2. Section	84	240	203	16	21(3)
3. Flat					
a. Hot Strip & Sheet	44	55	52	3	0
b. Plate	16	25	23	2	0
4. Hot Working Pipe & Tube	30	52	49	0	3
H. Scale Removal					
1. Kolene	19	24	19	5	0
2. Hydride	6	8	7	1	0
I. Acid Pickling					
1. Sulfuric Acid					
a. Batch	95	136	100	30	6(4)
b. Continuous	32	55	49	3	3(4)
2. Hydrochloric Acid					
a. Batch	7	7	6	1	0
b. Continuous	40	91	64	27	0
3. Combination Acid					
a. Batch	50	63	41	21	1(4)
b. Continuous	19	66	64	2	0

TABLE II-2
SUBCATEGORY INVENTORY
PAGE 3

Subcategory	No. of Plant Sites	No. of Individual Units (1)	No. of Units Direct Discharging	No. of Units Discharging to POTWs	No. of Units With Zero Discharges
J. Cold Forming					
1. Cold Rolling					
a. Recirculation	46	144	113	18	13
b. Combination	10	19	19	0	0
c. Direct Application	23	67	67	0	0
2. Pipe & Tube					
a. Water	20	72	22	24	26
b. Oil Emulsions	14	52	0	0	52
K. Alkaline Cleaning					
1. Batch	29	51	34	17	0
2. Continuous	36	123	94	29	0
L. Hot Coatings					
1. Galvanizing	63	146	100	34	12
2. Terne	5	6	5	1	0
3. Other Metals	9	18	5	13	0
TOTAL	1044	2027	1545	286	196

( ) For steelmaking operations, the numbers in parentheses represent the number of furnaces at the specified number of shops.

(1) Multiple operating units or pollution control facilities within a subcategory may exist at a plant site.

(2) These coke plant operations achieve zero discharge either by disposing of their effluent via quenching or deep well disposal.

(3) Number includes four dry operations.

(4) Zero discharge achieved in this subcategory in some instances by having wastewater hauled off-site.

TABLE II-3

PLANTS SAMPLED DURING IRON AND STEEL STUDY

Subcategory	Sampling Code	Plant Reference Code	Plant Name	Type of Operation
A. Cokemaking				
1. By-Product	001(1)	0732A	Shenango (Neville Island)	
	002	0464C	Koppers (Erie)	
	003(1)	0868A	U.S.S. (Fairfield)	
	+	0860H	U.S.S. (South Works)	
	006	0584B	National Steel (Great Lakes)	
	007	0320	Ford Motor Co. (Dearborn)	
	008	0920F	Wheeling-Pit (Follansbee)	
	009(1)	0684F	Republic STeel (Cleveland)	
	+	0402	Ironton Coke (Ironton)	
	A	0432B	J & L (Pittsburgh)	
	B	0112	Bethlehem (Bethlehem)	
	C	0384A	Inland (East Chicago)	
	D	0272	Donner-Hanna (Buffalo)	
2. Beehive	E	0428A	Jewell (Vansant)	
	F	0428A	Jewell (Vansant)	
	G	0724A	Sharon (Carpenter)	
B. Sintering				
	016	0112D	Bethlehem (Burns Harbor)	
	017	0432A	J & L (Aliquippa)	
	019	0060F	Armco (Houston)	
	H	0432A	J & L (Aliquippa)	

TABLE II-3
PLANTS SAMPLED DURING IRON AND STEEL STUDY
PAGE 2

Subcategory	Sampling Code	Plant Reference Code	Plant Name	Type of Operation
	I	0291C	International Harvester (Chicago)	
	J	0396A	Interlake (Chicago)	
	K	0112B	Bethlehem (Buffalo-Lackawanna)	
C. Ironmaking				
	021	0196A	CF&I (Pueblo)	Iron
	022	0856N	U.S.S. (Lorain)	Iron
	023	0860B	U.S.S. (Gary Works)	Iron
	024	0860H	U.S.S. (Chicago-South)	Iron
	025	0112C	Bethlehem (Johnstown)	Iron
	026	0112D	Bethlehem (Burns Harbor)	Iron
	027	0432A	J & L (Aliquippa)	Iron
	028	0684H	Republic (Chicago)	Iron
	029	0684F	Republic (Cleveland)	Iron
	030	0112	Bethlehem (Bethlehem)	Iron
	L	0291C	International Harvester (Chicago)	Iron
	M	0396A	Interlake (Chicago)	Iron
	N	0448A	Kaiser (Fontana)	Iron
	O	0060F	Armco (Houston)	Iron
	P	0112B	Bethlehem (Buffalo-Lackawanna)	Iron
	Q	0112C	Bethlehem (Johnstown)	FeMn
D. Steelmaking				
1. BOF	031	0020B	Allegheny-Ludlum (Brackenridge)	W-OC
	032	0384A	Inland (Indiana Harbor)	W-SC
	033	0856B	U.S.S. (Edgar Thompson)	W-OC
	034	0856N	U.S.S. (Lorain)	W-SC

TABLE II-3
PLANTS SAMPLED DURING IRON AND STEEL STUDY
PAGE 3

Subcategory	Sampling Code	Plant Reference Code	Plant Name	Type of Operation
	035	0868A	U.S.S. (Fairfield)	W-OC
	036	0112D	Bethlehem (Burns Harbor)	W-OC
	038	0684F	Republic (Chicago)	W-SC
	D*	0248A	Crucible (Midland)	W-OC
	R	0432A	J & L (Aliquippa)	Semi-wet
	S	0060	Armco (Middletown)	W-SC
	T	0112A	Bethlehem (Sparrows Point)	W-OC
	U	0396D	Interlake (Chicago)	Semi-Wet
	V	0584F	National (Weirton)	W-OC
2. Open Hearth	042	0492A	Lone Star (Lone Star)	Wet
	043	0864A	U.S.S. (Provo)	Semi-wet
	W	0112A	Bethlehem (Sparrows Point)	Wet
	Y	0060	Armco (Middletown)	Wet
3. Electric Arc Furnace	051	0612	Northwestern Steel & Wire (Sterling)	Wet
	052	0492A	Lone Star (Lone Star)	Wet
	059B	0060F	Armco (Houston)	Semi-wet
	AA	0060F	Armco (Houston)	Wet
	AB	0868B	U.S.S. (Texas Works, Baytown)	Wet
	Y	0432C	J & L (Cleveland)	Semi-wet
	Z	0584A & B	National (Ecorse)	Semi-wet

TABLE II-3
PLANTS SAMPLED DURING IRON AND STEEL STUDY
PAGE 4

Subcategory	Sampling Code	Plant Reference Code	Plant Name	Type of Operation
E. Vacuum Degassing				
	062	0496	Lukens (Coatesville)	
	065	0584F	National (Weirton)	
	068	0684H	Republic (Chicago)	
	AC	0584F	National (Weirton)	
	AD	0868B	U.S.S. (Texas Works, Baytown)	
	E	0020B	Allegheny-Ludlum (Brackenridge)	
	G	0856R	U.S.S. (Duquesne)	
F. Continuous Casting				
	071	0284A	Eastern Stainless (Baltimore)	
	072	0496	Lukens (Coatesville)	
	075	0584F	National (Weirton)	
	079	0060K	Armco (Marion)	
	AE	0584F	National (Weirton)	
	AF	0868B	U.S.S. (Texas Works, Baytown)	
	B*	0900	Washington Steel (Washington)	
	D*	0248A & B	Crucible (Midland)	
	Q*	0684D	Republic (Massilon)	
G. Hot Forming				
1. Primary	081	0176	Carpenter Technology (Reading)	Bloom
	082	0496 (140" only)	Lukens (Coatesville)	Slab/Rough Plate
	082	0496 (140",206" in tandem)	Lukens (Coatesville)	Slab/Rough Plate
	083	0860H	U.S.S. (South Chicago)	Slab/Bloom
	D*	0248B	Crucible (Midland)	Slab

TABLE II-3
PLANTS SAMPLED DURING IRON AND STEEL STUDY
PAGE 5

Subcategory	Sampling Code	Plant Reference Code	Plant Name	Type of Operation
	E*	0020B	Allegheny-Ludlum (Brackenridge)	Slab
	H*	0248A	Crucible (Midland)	Bloom
	K*	0256K	Universal Cyclops (Bridgeville)	Slab/Bloom
	M*	0432J	J & L (Warren)	Slab/Bloom
	Q*	0684D	Republic (Massillon)	Bloom
	R*	0240A	Copperweld (Warren)	Bloom
	A-2	0112B	Bethlehem (Lackawanna)	Bloom
	B-2	0112B	Bethlehem (Lackawanna)	Slab
	C-2 & 088 (Revisited)	0684H	Republic (Chicago)	Bloom
	D-2	0946A	Wisconsin (Chicago)	Bloom
	L-2	0060	Armco (Middletown)	Slab
2. Section	083	0860H (02 & 03)	U.S.S. (South Chicago)	34" & Rod Mill
	087	0432-02	J & L (Aliquippa)	14" Mill
	088	0684H-02	Republic (Chicago)	34" Mill
	088	0684H (01,03,05,06,07)	Republic (Chicago)	36",32",14",10",11" Mills
	C*	0424 (01-03)	Jessop (Washington)	Bar Mills
	H*	0248A	Crucible (Midland)	Merchant Mill
	K*	0256K	Universal Cyclops (Bridgeville)	Bar Mill
	M*	0432J	J & L (Warren)	Billet Mill
	O* & 081 (Revisited)	0176 (01-03)	Carpenter Technology (Reading)	Bar Mills
	A-2	0112B	Bethlehem (Lackawanna)	Rail Mill
	D-2	0946A	Wisconsin (Chicago)	#2, 3, & 6 Mills

TABLE II-3
PLANTS SAMPLED DURING IRON AND STEEL STUDY
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Subcategory	Sampling Code	Plant Reference Code	Plant Name	Type of Operation
	E-2	0196A (09 & 10)	CF&I (Pueblo)	Bar & Rod Mills
	F-2	0384A-06	Inland (East Chicago)	12" Bar Mill
	G-2	0652A (01 & 02)	Penn-Dixie (Joliet)	10" & 12" Mills
	H-2	0432A-04	J & L (Aliquippa)	Rod Mill
	I-2	08560	U.S.S. (Cleveland)	Rod Mill
3. Flat	082	0496 (01 & 03)	Lukens (Coatesville)	140",112"/120", 140"/206"
	082	0496 (02 & 04)	Lukens (Coatesville)	112"/120",140" Mills
	083	0860H-01	U.S.S. (South Chicago)	30" Plate Mill
	086	0112D-01	Bethlehem (Burns Harbor)	160" Plate Mill
	086	0112D-02	Bethlehem (Burns Harbor)	80 " Hot Strip
	087	0432A	J & L (Aliquippa)	44" Hot Strip
	D*	0248B	Crucible (Midland)	Hot Strip
	E*	0020B	Allegheny-Ludlum (Brackenridge)	Hot Strip
	F*	0856H	U.S.S. (Homestead)	160" Plate Mill
	O	0176	Carpenter Technology (Reading)	#4 Hot Mill
	J-2	0860B-01	U.S.S. (Gary Works)	84" Hot Strip
	K-2	0868B	U.S.S. (Baytown)	160" Plate Mill
	L-2	0060	Armco (Middletown)	Hot Strip & Sheet
	M-2	0384A-02	Inland (East Chicago)	80" Hot Strip
	N-2	0396D-02	Interlake (Riverdale)	#4 Hot Strip

TABLE II-3
PLANTS SAMPLED DURING IRON AND STEEL STUDY
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Subcategory	Sampling Code	Plant Reference Code	Plant Name	Type of Operation
4. Pipe and Tube	087	0432A-01	J & L (Aliquippa)	Butt Weld
	088	0684H	Republic (Chicago)	Seamless
	E-2	0196A-01	CF&I (Pueblo)	Seamless
	GG-2	0240B-05	Ohio Steel & Tube (Shelby)	Seamless
	II-2	0916A	Wheatland (Wheatland)	Butt Weld
	JJ-2	0728	Sharon (Sharon)	Butt Weld
	KK-2	0256G	Cyclops (Sawhill)	Butt Weld
H. Scale Removal				
1. Kolene	131	0424	Jessop (Washington, Pennsylvania)	Plate
	132	0176-04	Carpenter Technology (Reading)	Rod, Wire
	138	0440A	Joslyn (Fort Wayne)	Bar, Rod
	C*	0424	Jessop (Washington, Pennsylvania)	Plate
	L*	0440A	Joslyn (Fort Wayne)	Bar,Rod
2. Hydride	132	0176 (01-03)	Carpenter Technology (Reading)	Bar,Rod Strip,Wire
	139	0256N	Universal Cyclops (Titusville)	Bar,Billet
	L*	0440A	Joslyn (Fort Wayne)	Bar,Rod
	Q*	0684D	Republic (Massillon)	Strip
I. Acid Pickling				
1. Sulfuric Acid	092	088A	B&W (Beaver Falls)	B
	094	0948C	YS&T (Indiana Harbor)	C-N
	095	0584E	National (Midwest)	C
	096	01121	Bethlehem (Lebanon)	B-N
	097	0760	Stanley (New Britain)	C-AU

TABLE II-3
PLANTS SAMPLED DURING IRON AND STEEL STUDY
PAGE 8

Subcategory	Sampling Code	Plant Reference Code	Plant Name	Type of Operation
	098	0684P	Republic (Massillon)	B
	R*	0240A	Copperweld (Warren)	B-N
	H-2	0432A	J & L (Aliquippa)	B-N, C-N
	I-2	0856P	U.S.S. (Cleveland)	B
	O-2	0590	Nelson Steel (Chicago)	B-AU
	P-2	0312	Fitzsimons (Youngstown)	B-AU
	Q-2	0894	Walker Steel & Wire (Ferndale)	B-AU
	R-2	0240B	Ohio Sheet & Tube (Shelby)	B-N
	S-2	0256G	Cyclops-Sawhill (Sharon)	B-N
	T-2	0792B	Thompson Steel (Chicago)	C-AU
	QQ-2	0584E	National (Midwest)	C-N
	SS-2	0112A	Bethlehem (Sparrows Pt.)	C-N
	TT-2	0856D	U.S.S. (Irwin)	C-N
	WW-2	0868A	U.S.S. (Fairfield)	C-N
2. Hydrochloric Acid	091	0612	Northwestern S&W (Sterling)	C-N
	093	0396D	Interlake (Riverdale)	C-N
	095	0584F	National (Weirton)	C-AR
	099	0528B	McLouth (Gibralter)	C-AR
	100	0384A	Inland (East Chicago)	C-N
	I-2	0856P	U.S.S. (Cuyahoga)	C-N
	U-2	0480A	LaSalle (Hammond)	B-N
	V-2	0936	Wire Sales, Inc. (Chicago)	B-N
	W-2	-	Dominion (Hamilton)	C-AR
	X-2	0060B	Armco (Ashland)	C-AR
	Y-2	-	Steel Co. of Canada (Hamilton)	C-AR
	Z-2	0396D	Interlake (Riverdale)	C-N
	AA-2	0384A	Inland (East Chicago)	C-N
	BB-2	0060	Armco (Middletown)	C-N

TABLE II-3
PLANTS SAMPLED DURING IRON AND STEEL STUDY
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Subcategory	Sampling Code	Plant Reference Code	Plant Name	Type of Operation
3. Combination Acid	121	0900	Washington Steel (Washington)	C-N
	122	0176	Carpenter Technology	B-N
	123	0088A	Babcock & Wilcox (Beaver Falls)	B-N
	124	0088D	Babcock & Wilcox (Koppel)	B-N
	125	0674E	Plymouth Tube (Dunkirk)	B-N
	A*	0900	Washington Steel (Washington)	C-N
	C*	0424	Jessop (Washington, Pennsylvania)	B-N
	D*	0248A & B	Crucible (Midland)	C-N
	F*	0856H	U.S.S. (Homestead)	B-N
	I*	0432K	J & L (Louisville)	C-N
	L*	0440A	Joslyn (Fort Wayne)	B-N
	O*	0176	Carpenter Technology	C-N
	U*	00600	Tube Associates (Houston)	B-N
J. Cold Forming				
1. Cold Rolling	101 A & B	0020 B & C	Allegheny-Ludlum (W. Lerchburg)	Recirc.
	102	0384A	Inland (East Chicago)	Recirc.
	103	0856F	U.S.S. (Fairless)	Combination
	104	0248B	Crucible (Midland)	Recirc.
	105	0584F	National (Weirton)	Direct Appl.
	105	0584F	National (Weirton)	Recirc.
	106	0112B	Bethlehem (Lackawanna)	Direct Appl.
	107	0176	Carpenter Technology (Reading)	Recirc.
	107	0176	Carpenter Technology (Reading)	Direct Appl.
	D*	0248B	Crucible (Midland)	Recirc.
	I*	0432K	J & L (Louisville)	Recirc.
	P*	0156B	Cabot Steel (Kokomo)	Recirc.
	X-2	0060B	Armco (Ashland)	Recirc.
	BB	0060	Armco (Middleton)	Recirc.
	DD-2	0584E	National (Midwest)	Combination
	EE-2	0112D	Bethlehem (Burns Harbor)	Recirc.
	FF-2	0384A	Inland (East Chicago)	Recirc.
	VV-2	0584F	National (Weirton)	Direct Appl.
	XX-2	0684I	Republic (Gadsden)	Recirc.
	YY-2	0432D	J & L (Hennepin)	Combination

TABLE II-3
PLANTS SAMPLED DURING IRON AND STEEL STUDY
PAGE 10

Subcategory	Sampling Code	Plant Reference Code	Plant Name	Type of Operation
2. Pipe and Tube	HH-2	0492A	Lone Star Steel (Lone Star)	Water
K. Alkaline Cleaning	152	0176	Carpenter Technology (Reading)	Continuous
	156	0112I	Bethlehem (Lebanon)	Batch & Cont.
	157	0432K	J & L (Louisville)	Cont.
	I*	0432K	J & L (Louisville)	Cont.
L. Hot Coating				
1. Galvanizing	111	0612	Northwestern Steel (Sterling)	
	112	0396D	Interlake (Riverdale)	
	114	0948C	YS&T (East Chicago)	
	116	0112I	Bethlehem (Lebanon)	
	118	0920E	Wheeling-Pitt (Martins Ferry)	
	119	0476A	Laclede (Alton)	
	I-2	0856O	U.S.S. (Cleveland)	
	V-2	0936	Wire Sales (Chicago)	
	MM-2	0856F	U.S.S. (Fairless)	
	NN-2	0920E	Wheeling-Pitt (Martins Ferry)	
2. Terne	113	0856D	U.S.S. (Irwin)	
	OO-2	0060R	Armco (Middletown)	
	PP-2	0856D	U.S.S. (Irwin)	
3. Other	116	0112I	Bethlehem (Lebanon)	Aluminum

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(1) Data exists for more than one visit.
+: Data not included in the subcategory report.
*: Sampled by Datagraphics.

Key to Abbreviations:

W-OC: "Wet-Open Combustion" type air pollution control system.
W-SC: "Wet-Suppressed Combustion" type air pollution control system
B: Batch
C: Continuous
AU: Acid Recovery
AR: Acid Regeneration

TABLE II-4

INDUSTRY-WIDE DATA BASE
IRON & STEEL INDUSTRY

	No. of Operations
Number Sampled for Original Guidelines Study	133
Number Sampled for Toxic Pollutant Study	114
Total Number Sampled (Not including re-visits)	206
Number Responding to the D-DCP's	174 incl. 44 above
Total Number Sampled or Surveyed via D-DCP's	336
Number Responding to the DCP's	2027

TABLE II-5

REVISED STEEL INDUSTRY SUBCATEGORIZATION

A. Cokemaking

  1. Byproduct
  2. Beehive

B. Sintering

C. Ironmaking

D. Steelmaking

  1. BOF

    a. Semi-wet
    b. Wet - Open Combustion
    c. Wet - Suppressed Combustion

  2. Open Hearth

    a. Semi-wet
    b. Wet

  3. Electric Arc Furnace

    a. Semi-wet
    b. Wet

E. Vacuum Degassing

F. Continuous Casting

G. Hot Forming

  1. Primary

    a. Carbon and Specialty w/o scarfing
    b. Carbon and Specialty w/scarfing

  2. Section

    a. Carbon
    b. Specialty

    3. Flat

        a. Hot Strip and Sheet (Carbon and Specialty)
        b. Plate - Carbon
        c. Plate - Specialty

    4. Pipe and Tube

H. Scale Removal

    1. Kolene
    2. Hydride

I. Acid Pickling

    1. Sulfuric Acid

        a. Acid Recovery - Batch
        b. Acid Recovery - Continuous
        c. Neutralization - Batch
        d. Neutralization - Continuous

    2. Hydrochloric Acid

        a. Acid Regeneration
        b. Neutralization - Batch
        c. Neutralization - Continuous

    3. Combination Acid Pickling

        a. Batch
        b. Continuous

J. Cold Forming

    1. Cold Rolling

        a. Recirculation
        b. Combination
        c. Direct Application

    2. Pipe and Tube

        a. Water
        b. Oil Emulsion

K. Alkaline Cleaning

TABLE II-5
REVISED STEEL INDUSTRY SUBCATEGORIZATION
PAGE 3

L. Hot Coatings

   1. Galvanizing

      a. Strip, Sheet, and Miscellaneous Products without scrubbers
      b. Strip, Sheet, and Miscellaneous Products with scrubbers
      c. Wire Products and Fasteners without scrubbers
      d. Wire Products and Fasteners with scurbbers

   2. Terne

      a. Without scrubbers
      b. With scrubbers

   3. Other Coatings

      a. Strip, Sheet, and Miscellaneous Products without scrubbers
      b. Strip, Sheet, and Miscellaneous Products with scrubbers
      c. Wire Products and Fasteners without scrubbers
      d. Wire Products and Fasteners with scrubbers

TABLE II-6

CROSS REFERENCE OF REVISED STEEL INDUSTRY SUBCATEGORIZATION TO PRIOR SUBCATEGORIZATION

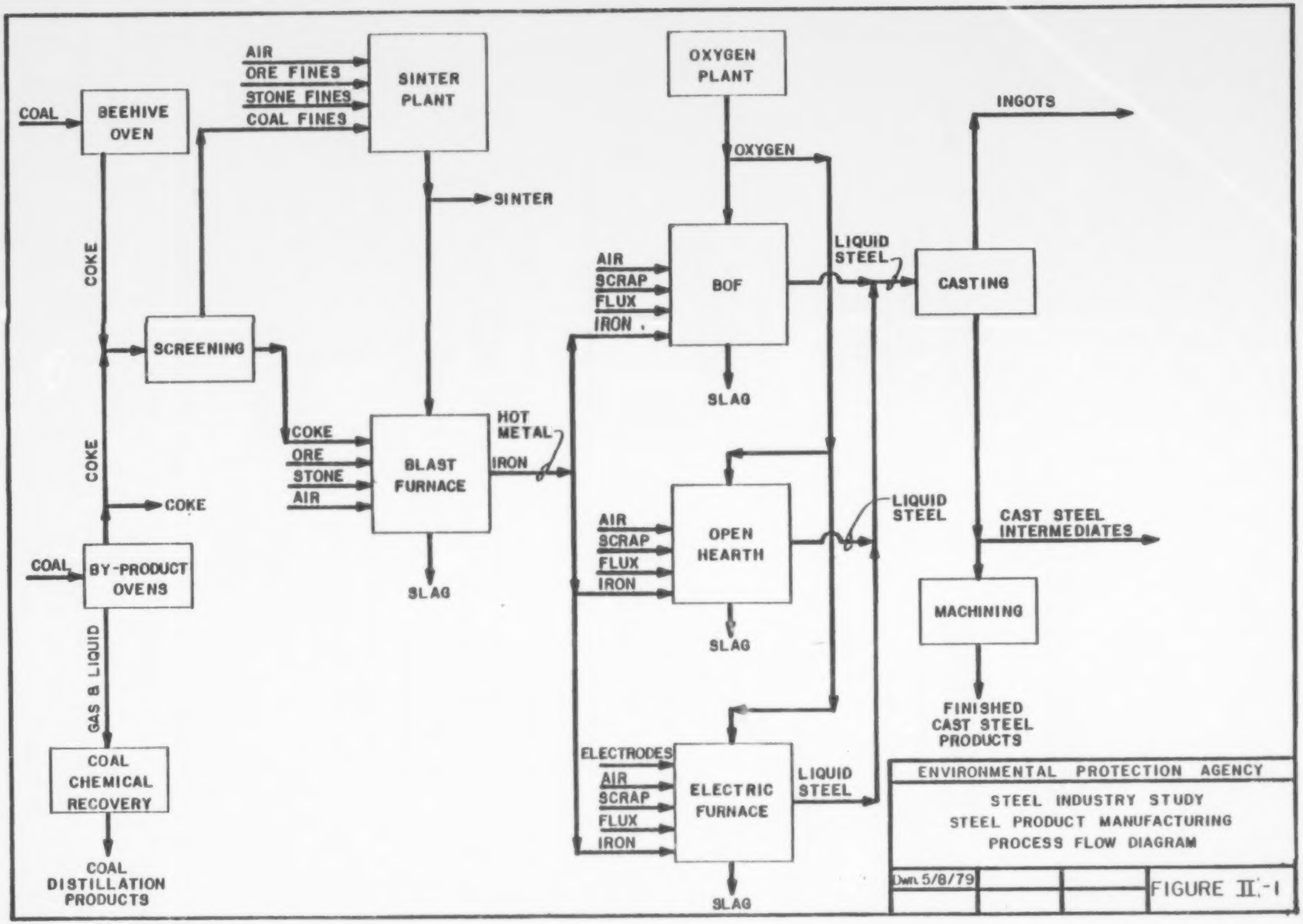
Revised Subcategorization (1980 Regulations)	Prior Subcategorization (1974 and 1976 Regulations)	Remarks
A. Cokemaking	A. By-Product Coke	
1. By-Product	B. Beehive Coke	
2. Beehive		
B. Sintering	C. Sintering	
C. Blast Furnace	D. Blast Furnace - Iron	
	E. Blast Furnace - FeMn	
D. Steelmaking		
1. BOF	F. BOF - Semi-wet	
a. Semi-wet	G. BOF - Wet	
b. Wet - Open Combustion		
c. Wet - Suppressed Combustion		(New Segment)
2. Open Hearth		
a. Semi-wet		(New Segment)
b. Wet	H. Open Hearth - Wet	
3. EAF	I. EAF - Semi-wet	
a. Semi-wet	J. EAF - Wet	
b. Wet		
E. Vacuum Degassing	K. Vacuum Degassing	
F. Continuous Casting	L. Continuous Casting	
G. Hot Forming	M. Hot Forming - Primary	
1. Primary	1. Carbon wo/scarfers	
	2. Carbon w/scarfers	
a. Carbon and Specialty wo/scarfers	3. Specialty	
b. Carbon and Specialty w/scarfers		

TABLE II-6
CROSS REFERENCE OF REVISED STEEL INDUSTRY
SUBCATEGORIZATION TO PRIOR SUBCATEGORIZATION
PAGE 2

Revised Subcategorization (1980 Regulations)	Prior Subcategorization (1974 and 1976 Regulations)	Remarks
2. Section	N. Hot Forming - Section	
a. Carbon	1. Carbon	
b. Specialty	2. Specialty	
3. Flat	O. Hot Forming - Flat	
a. Hot Strip and Sheet	1. Hot Strip & Sheet	
b. Plate	2. Plate	
(1) Carbon	a. Carbon	
(2) Specialty	b. Specialty	
4. Pipe and Tube	P. Hot Forming - Pipe and Tube	
	1. Isolated	
	2. Integrated	
H. Scale Removal	X. Scale Removal	
1. Kolene	a. Kolene	
2. Hydride	b. Hydride	
I. Acid Pickling	Q. Pickling - Sulfuric Acid - Batch and Continuous	
1. Sulfuric Acid	a. Batch - spent liquor, no rinses	
a. Acid Recovery - Batch	b. Continuous - Neutralization (liquor)	
b. Acid Recovery - Continuous		
c. Neutralization - Batch	c. Continuous - Neutralization (R, FHS)	
d. Neutralization - Continuous		
	d. Continuous - Acid Recovery (new facilities)	
2. Hydrochloric Acid	R. Pickling - Hydrochloric Acid - Batch and Continuous	
a. Acid Regneration	a. Concentrates - nonregenerative	
b. Neutralization - Batch	b. Regeneration	
c. Neutralization - Continuous	c. Rinses	
	d. Fume hood scrubbers	

TABLE II-6
CROSS REFERENCE OF REVISED STEEL INDUSTRY
SUBCATEGORIZATION TO PRIOR SUBCATEGORIZATION
PAGE 3

Revised Subcategorization (1980 Regulations)	Prior Subcategorization (1974 and 1976 Regulations)	Remarks
3. Combination Acid	W. Combination Acid Pickling (Batch and Continuous) Subcategory	
a. Batch b. Continuous	a. Continuous b. Batch - Pipe and Tube c. Batch - other	
J. Cold Forming		
1. Cold Rolling	S. Cold Rolling	
a. Recirculation	a. Recirculation	
b. Combination	b. Combination	
c. Direct Application	c. Direct Application	
2. Pipe and Tube		
a. Water		(New Segment)
b. Oil emulsion		(New Segment)
K. Alkaline Cleaning	Z. Continuous Alkaline Cleaning	
L. Hot Coatings		
1. Galvanizing	T. Hot Coatings - Galvanizing	
a. Strip, Sheet, and Miscellaneous Products	a. Galvanizing	
b. Wire Products and Fasteners	b. Fume hood scrubber	
2. Terne	U. Hot Coatings - Terne	
3. Other Coatings		
a. Strip, Sheet, and Miscellaneous Products		(New Segment)
b. Wire Products and Fasteners		(New Segment)

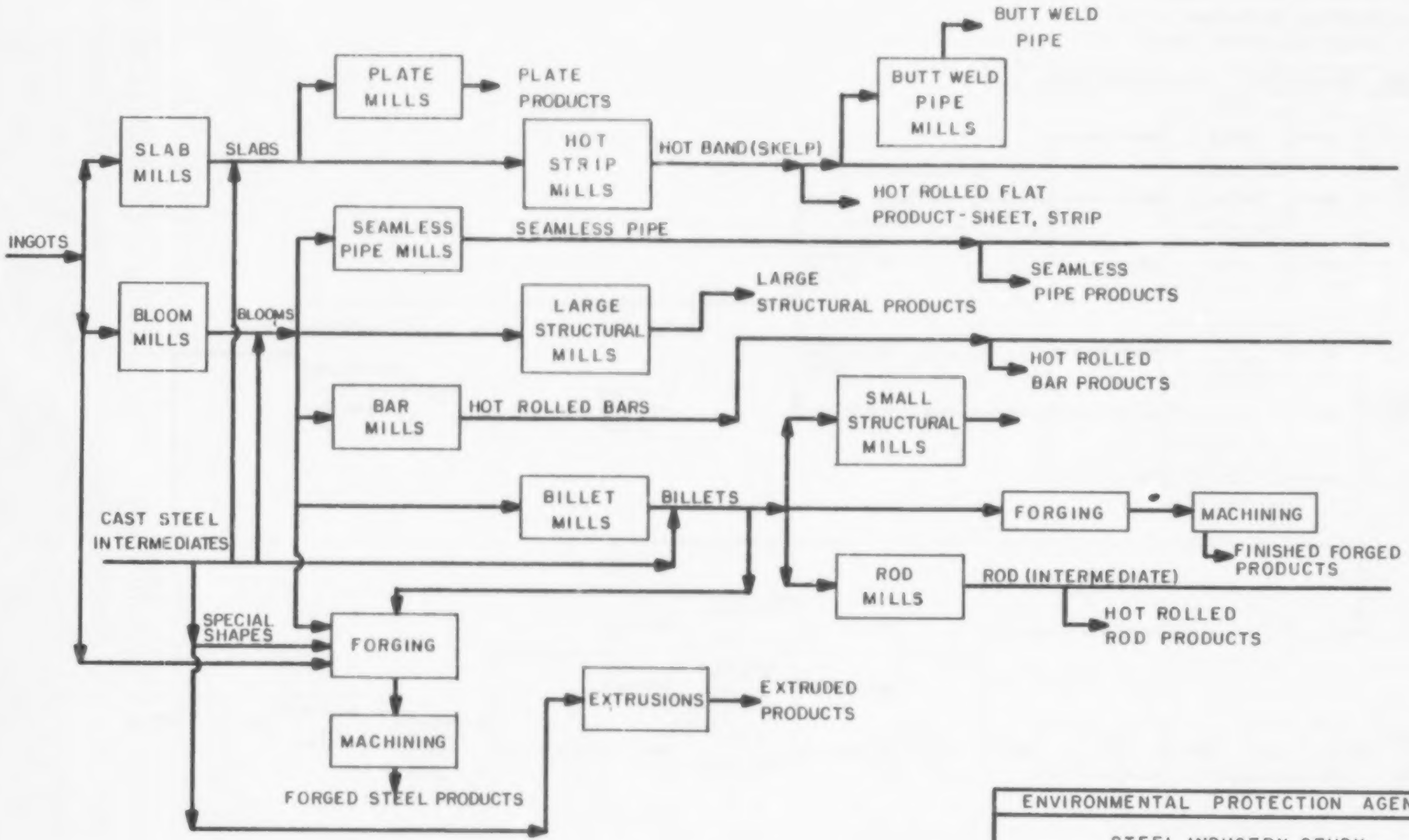

COAL
BEEHIVE OVEN
COKE
SCREENING
COKE
COKE
COAL
BY-PRODUCT OVENS
GAS & LIQUID
COAL CHEMICAL RECOVERY
COAL DISTILLATION PRODUCTS
AIR
ORE FINES
STONE FINES
COAL FINES
SINTER PLANT
SINTER
COKE
ORE
STONE
AIR
BLAST FURNACE
SLAG
HOT METAL
IRON
OXYGEN PLANT
OXYGEN
AIR
SCRAP
FLUX
IRON
BOF
SLAG
LIQUID STEEL
AIR
SCRAP
FLUX
IRON
OPEN HEARTH
SLAG
LIQUID STEEL
ELECTRODES
AIR
SCRAP
FLUX
IRON
ELECTRIC FURNACE
SLAG
LIQUID STEEL
CASTING
INGOTS
CAST STEEL INTERMEDIATES
MACHINING
FINISHED CAST STEEL PRODUCTS

ENVIRONMENTAL PROTECTION AGENCY

STEEL INDUSTRY STUDY
STEEL PRODUCT MANUFACTURING
PROCESS FLOW DIAGRAM

Dwn. 5/8/79

FIGURE II-1

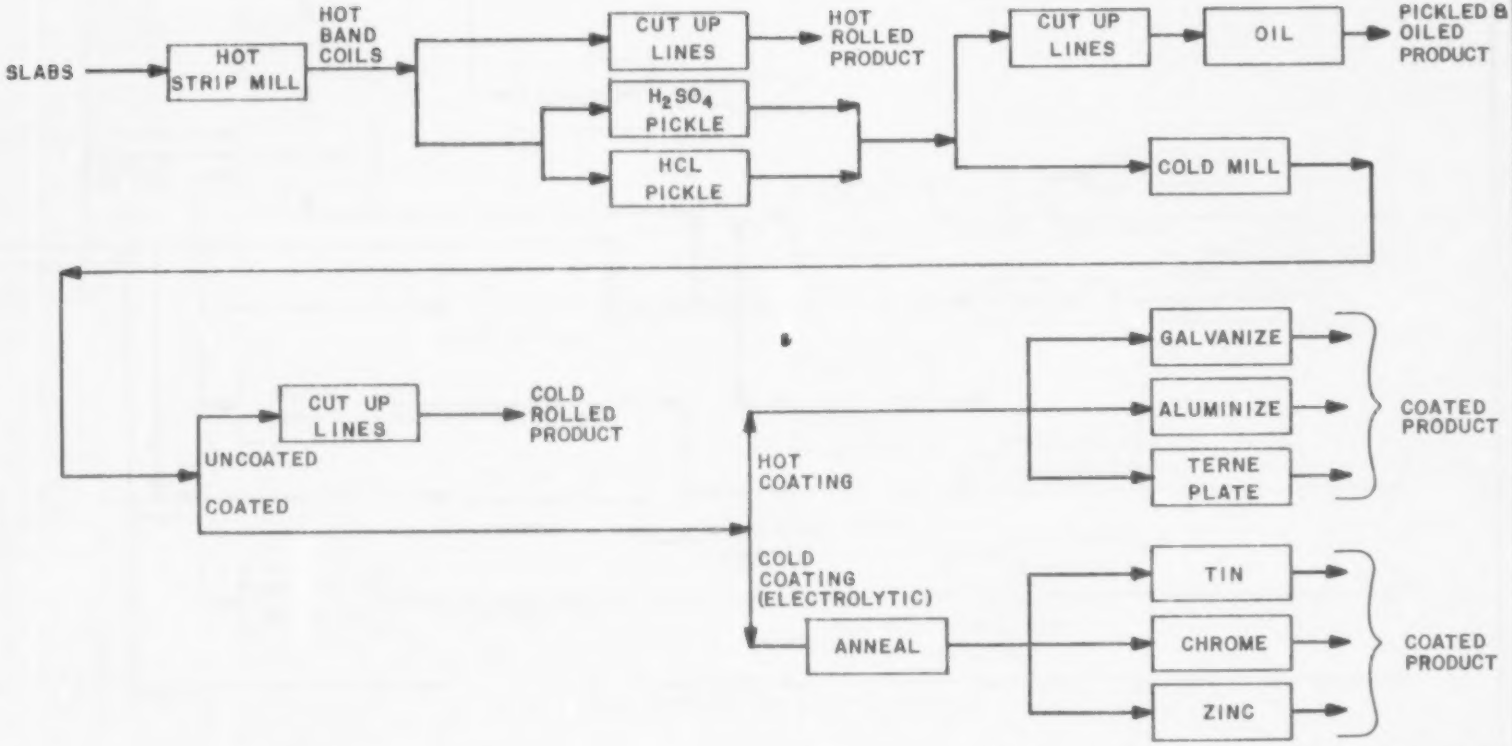

INGOTS
SLAB MILLS
SLABS
BLOOM MILLS
BLOOMS
CAST STEEL INTERMEDIATES
SPECIAL SHAPES
PLATE MILLS
PLATE PRODUCTS
HOT STRIP MILLS
HOT BAND (SKELP)
BUTT WELD PIPE MILLS
BUTT WELD PIPE
HOT ROLLED FLAT PRODUCT - SHEET, STRIP
SEAMLESS PIPE MILLS
SEAMLESS PIPE
SEAMLESS PIPE PRODUCTS
LARGE STRUCTURAL MILLS
LARGE STRUCTURAL PRODUCTS
BAR MILLS
HOT ROLLED BARS
HOT ROLLED BAR PRODUCTS
SMALL STRUCTURAL MILLS
BILLET MILLS
BILLETS
FORGING
MACHINING
FINISHED FORGED PRODUCTS
ROD MILLS
ROD (INTERMEDIATE)
HOT ROLLED ROD PRODUCTS
FORGING
MACHINING
FORGED STEEL PRODUCTS
EXTRUSIONS
EXTRUDED PRODUCTS

ENVIRONMENTAL PROTECTION AGENCY

STEEL INDUSTRY STUDY
HOT FORMING
PROCESS FLOW DIAGRAM

Dwn. 4/25/79

FIGURE II - 2


SLABS
HOT STRIP MILL
HOT BAND COILS
CUT UP LINES
HOT ROLLED PRODUCT
H_2SO_4 PICKLE
HCL PICKLE
CUT UP LINES
OIL
PICKLED & OILED PRODUCT
COLD MILL
UNCOATED
COATED
CUT UP LINES
COLD ROLLED PRODUCT
HOT COATING
COLD COATING (ELECTROLYTIC)
ANNEAL
GALVANIZE
ALUMINIZE
TERNE PLATE
COATED PRODUCT
TIN
CHROME
ZINC
COATED PRODUCT

ENVIRONMENTAL PRODUCTION AGENCY

STEEL INDUSTRY STUDY
FLAT PRODUCTS GENERAL
PROCESS FLOW DIAGRAM

Dwn. 7/15/80

FIGURE II-3

VOLUME I

SECTION III

REMAND ISSUES ON PRIOR REGULATIONS

Introduction

After reviewing the 1974 (Phase I) and 1976 (Phase II) regulations for the steel industry, the Court of Appeals ordered EPA to reconsider several matters. This section provides a general summary of EPA's evaluation of the "remand issues". The respective subcategory reports provide the Agency's response to subcategory specific remand issues.

1. Site-Specific Costs

In its challenge to the Phase I regulation, the industry asserted that EPA's cost estimates did not include allowances for "site-specific costs." EPA responded that it included all costs which could be reasonably estimated (the industry had submitted no data showing the magnitude of "site-specific costs") and that it believed its estimates were sufficiently generous to cover site-specific costs. On this basis, the court rejected this challenge to the regulation. American Iron and Steel Institute v. EPA, 526 F.2d 1027 (3d Cir. 1975), modified in part, 560 F.2d 589 (3d Cir. 1977), cert. den. 98 S. Ct 1467 (1978).

In the Phase II proceedings, however, evidence of the possible magnitude of "site-specific" cost was presented.[4] On this basis, the court ordered EPA to reevaluate its cost estimates in light of "site-specific costs." In particular, the court ordered EPA to include these costs, or analyze the generosity of its estimates by comparing model cost estimates with actual reported costs, or explain why such an analysis could not be done.

In response the the court's decisions, EPA has reevaluated its cost estimates for Phase I and Phase II operations. First, the Agency included in its estimates many "site-specific" costs which were not included in prior estimates.[5] In EPA's view, it has included all "site-specific costs" that can be reasonably and accurately estimated without site-specific studies. The remaining "site-specific" costs not included are so highly variable and inherently site-specific that reasonably accurate estimates would require inspection of each operation in the country, obviously beyond EPA resources and time constraints and beyond the intent of the Act. It should be noted that studies commissioned by AISI, itself, also exclude site-specific costs. For example, in Arthur D. Little's Steel and the Environment - A Cost Impact Analysis, site-specific costs and land acquisition costs were excluded "...because detailed site-specific studies would be required."

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[4] This evidence consisted of the plant-by-plant compliance estimates for facilities located in the Mahoning Valley region of Eastern Ohio.

[5] These newly added cost items include: land acquisition costs, site clearance costs, utility connections, and some miscellaneous utility requirements.

Second, EPA has included in its cost estimates allowances for unforeseen expenses. The model-based cost estimates for each subcategory include a 15% contingency fee.[6]

Third, the Agency has based its cost estimates on many conservative assumptions. For instance, in most subcategories, EPA's cost estimates are based on individual treatment of each process waste stream. In fact, however, many plants have installed and will continue to install less costly "central treatment" systems to treat combined waste streams.[7] Additionally, EPA's model based estimates reflect off-the-shelf parts and costs for "outside" engineering and construction services.[8] In fact, however, the industry often uses "in-house" engineering and construction resources, and improve wastewater quality by "gerrymandering" existing treatment systems and upgrading operating and maintenance practices. EPA's cost estimates reflect treatment in place as of 1976 and treatment to have been installed by January, 1978. In fact, the industry has installed or is in the process of installing additional treatment systems.

Fourth, EPA has compared its model-based cost estimates to the costs reported by the industry. This comparison shows that EPA's estimates are sufficiently generous to reflect all costs, including "site-specific" costs. Before proceeding to this analysis, some preparatory comments are in order. Model-based estimates cannot be expected to precisely reflect the costs incurred or to be incurred by each individual plant. Variations of ±50% would not be considered outside normal confidence levels. For example, in Steel and the Environment - A Cost Impact Analysis, a study commissioned by AISI, itself, Arthur D. Little indicated that its cost estimates were within ± 50% for individual process steps and ± 85% for individual plants.[9] Often, variations from model estimates cannot be explained. The validity of model estimates, therefore, should be judged by the ability to depict actual costs for subcategories of the industry or for the industry, as a whole.

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[6] This contingency fee also was included in previous cost estimates.

[7] In the hot forming subcategory, however, EPA's estimates do reflect cost savings from "central treatment" within the subcategory but not across subcategories other than hot forming.

[8] The model estimates includes 15% for engineering services.

[9] See pages B-64 and B-65 of Steel and the Environment - A Cost Impact Analysis which AISI submitted to EPA during the Phase II rulemaking.

EPA's comparison of model-based cost estimates and costs reported by industry involved two complimentary analyses. First, the Agency compared actual reported treatment costs (including all site-specific costs) to the model cost estimates for the treatment components in place at the reporting plant. These comparisions include all plants providing sufficiently detailed cost information, regardless of the level of treatment in place. To generate valid comparisons, the model cost estimate was scaled to the actual production of the reporting plant by the application of the accepted engineering "six-tenths" factor. EPA scaled production of the model to actual production of the reporting plant because, in its view, this produces the most reliable cost comparison. Another possible method of comparison would be to scale the flow of the model to the actual flow of the reporting plant. This method of scaling would overstate treatment costs because those costs are highly dependent on flow volume (higher flows require larger and more costly treatment systems) and many plants in the industry use and discharge more water than necessary. Also, flow data are not available for all plants while production data are known for most operations and plants in the industry. This comparative analysis is summarized below for those subcategories where reliable subcategory-specific reported costs were found:

Treatment In Place v. Model Estimates for Same Treatment

Subpart (process)	Reported Cost ($\$x10^{-6}$)	Model Estimate ($\$x10^{-6}$)	Actual as % of Model
A. Cokemaking	63.65	77.01	83
B. Sintering	6.43	8.60	75
C. Ironmaking	100.56	115.01	87
D. Steelmaking	37.61	47.74	79
E. Vacuum Degassing	3.39	6.45	51
F. Continuous Casting	29.38	23.00	128
L. Hot Coatings	4.24	6.64	64
Total	245.26	284.45	86.2

This summary shows that actual reported costs for the industry (including all site-specific costs) represent about 86% of the model estimates for the same treatment components. On this basis, EPA concludes that its model estimates are sufficiently generous to reflect site-specific costs.

In the second comparison of reported costs and model estimates, EPA compared the reported costs (including all site-specific costs) of plants meeting BPT (or BAT) to the model estimate for the BPT (or BAT) treatment system. This methodology, which EPA presented in its brief in the Phase II proceedings, demonstrates that required effluent levels can be achieved by treatment systems described by EPA at estimated costs comparable to actual reported costs. This comparison, also involving scaling of production by the "six-tenths factor," is summarized below:

SUMMARY

Complying Plant Costs v. Model Compliance Estimates

Subcategory (process)	Reported Cost ($\$\text{x}10^{-6}$)	Model Estimate ($\$\text{x}10^{-6}$)	Actual as % of Model
A. Cokemaking	40.71	40.60	100
B. Sintering	5.92	6.35	93
C. Ironmaking	33.16	51.97	64
D. Steelmaking	37.61	47.74	79
E. Vacuum Degassing	2.08	2.48	84
F. Continuous Casting	19.36	18.61	104
Total	138.84	167.75	82.8

Again, this summary shows that total reported costs (including all site-specific costs) for plants meeting required effluent levels is only about 83% of model estimates. On this basis, EPA likewise concludes that its model-based cost estimates are sufficiently generous to reflect site-specific costs.

As noted in the subcategory reports for many of the Phase II operations, central treatment of wastewaters from finishing operations is common in the steel industry. The cost data reported by the industry for these central treatment systems are often not directly usable for the purpose of verifying the Agency's cost estimates for individual subcategory treatment systems. As noted earlier, the Agency considered co-treatment of wastewaters at plants within subcateogries, but did not consider co-treatment or control treatment across subcategories in developing cost estimates. To determine the impact of the extensive amount of central treatment in the industry on the Agency's ability to accurately estimate costs, the Agency compared actual industry control treatment costs with the Agency's model based cost estimates for the respective subcategories included in the industry's central treatment systems. This comparison is shown below.

TREATMENT IN PLACE vs MODEL ESTIMATES FOR CENTRAL TREATMENT

PLANT	SUBCATEGORIES	ACTUAL COST	MODEL COST
0112B	Hot Forming (Primary, Section)	$ 2,578,000	$ 5,747,000
0112H	Pickling (HCl, Combination)	746,000	1,451,000
0432K	Pickling, Scale Removal, Alkaline Cleaning	935,000	2,500,000
0796 & 0796A	Vacuum Degassing, Continuous Casting, Hot Forming (Primary, Section, Pipes and Tube), Pickling (H_2SO_4), Cold Rolling	16,770,000	15,793,000
0868A	Cold Rolling, Pickling (HCl, H_2SO_4), Hot Coating, Alkaline Cleaning	4,857,000	10,109,000
0868A	Hot Forming (Primary, Section)	303,000	3,890,000
0176	Hot Forming (Primary and Section), Cold Rolling (Direct Application), Cold Worked Pipe and Tube, Pickling (HCl, H_2SO_4, Combination), Scale Removal, Alkaline Cleaning	2,775,000	4,720,000
0460A	Hot Forming (Primary, Section)	340,000	2,534,000
0612	Hot Coating (Galvanizing), Pickling (HCl)	1,645,000	2,106,000
0728	Hot Forming (Pipe and Tube), Pickling (H_2SO_4), Hot Coating (Galvanizing)	220,000	1,192,000
	TOTAL	31,169,000	50,042,000

These data clearly indicate that in total, the Agency's estimates for separate subcategory-specific treatment systems far exceed those costs reported by the industry for central treatment. Of particular interest are the data reported for plants 0796-0796A which are for a control treatment facility that achieves the proposed BAT limitations for the operations included in the central treatment facility. The Agency's estimate is within six percent of the actual cost reported by the company. This system includes several miles of retrofitted wastewater collection and distribution piping not likely to be included in most central treatment systems. Based upon the above, the Agency concludes that its separate subcategory-specific cost estimates for the Phase II operations are sufficiently generous to include those site specific costs likely to be incurred for most central treatment facilities, and may be overly generous in depicting potential costs for steel finishing operations as a whole.

Another approach to judging the sufficiency of the Agency's model estimates to account for "site-specific" costs involved the analysis of compliance estimates for several mills located in the Mahoning Valley of Ohio. These studies, which were completed in 1977, estimated the cost of compliance with the previously promulgated and proposed Phase I and Phase II requirements for eight of the oldest plants in the country. Estimated compliance costs were furnished by the owners of the plants, based on actual site inspections and engineering studies, and were verfied by EPA's engineering contractor.

The tables summarizing those studies, which were part of the record of the Phase II rulemaking, are reproduced as Tables III-1 through III-3. Table III-1 summarizes the estimated compliance costs for Youngstown Sheet and Tube Corporation's Brier Hill, Campbell, and Struthers Works. Column #1 shows YS&T's estimate of BAT compliance costs, totaling $54,106,000, including all site-specific costs.[10] EPA's contractor estimated $51,214,000, as shown in Column #2. In Columns #3 and #4, EPA's contractor scaled the flow and production of the BAT cost model to the actual flow and production of the mills involved, yielding cost estimates of $53,218,000 and $60,568,000, respectively. By either method of scaling, EPA's estimate (including all site-specific costs) is representative of YS&T's estimate. In fact, the estimate scaled by production (the method now used for all cost estimations) more than accounted for the significant "site-specific" costs the industry claimed the model could not reflect.[11]

Analyses of estimated compliance costs for facilities owned by United States Steel Corporation and Republic Steel Corporation yield similar results. Table III-2 shows that U.S. Steel's $33,110,000 BAT estimate (including $13,145,000 site costs) for its McDonald Mills and Ohio Works plants was within 4% of EPA's model estimate of $34,389,000 (scaled by production). Similarly, Table III-3 shows that Republic Steel's BPT estimate of $70,099,000 (including $15,590,000 site costs) for its Warren, Youngstown, and Niles plants was withing 4% of EPA's model estimated of $72,640,000 for physical/chemical treatment (scaled by production) and within 5% of EPA's model estimate of $73,486,000 for biological treatment (scaled by production).

As a final comparison, EPA has compared its model cost[12] estimate against those prepared by an engineering company for a treatment system for a blast furnace facility. This company costed the BAT-2 system for blast furnaces and supplied its cost estimate to the Agency in its comments to the October 1979 draft development document. The company's cost and flow basis is compared below to the estimate made by the Agency. Both estimates are based upon the same model size ironmaking operation.

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[10] Column #5 reflects the judgment of EPA's contractor that YS&T's $54,106,000 estimate (Column #1) included "site-specific" costs of $18,176,000.

[11] Columns #6 and #7 add site-specific costs to model estimates scaled by flow and production, yielding $71,394,000 and $78,744,000, respectively. If accurate estimation required addition of "site-specific" costs to model estimates, as industry claimed, then YS&T's compliance costs would be overstated by $17,288,000 (scaled by flow) or $24,638,000 (scaled by production).

[12] Volume 3, Draft Development Document for Proposed Effluent Limitations Guidelines and Standards for the Iron and Steel Manufacturing Point Source Category; EPA 440/1-79/024a, October 1979.

	EPA Estimate	Company Estimate
Flow	50 gal/ton	100 gal/ton
Capital	$2.49 million	$3.94 million

If both estimates are costed on the same flow basis (100 gal/ton) the costs are as follows:

EPA Estimate	Company Estimate
$3.78 million	$3.94 million

These data show that EPA's estimate is within 4.1% of the unsolicited estimate made by the engineering firm. This comparison further substantiates the reasonableness and accuracy of the Agency's cost models and costing methodology.

In summary, EPA has thoroughly reevaluated its model cost estimates in light of "site-specific" costs. It has added additional site costs to the models (see Section VII); included contingency fees in the models; used conservative cost assumptions; compared reported costs for treatment in place to model estimates for similar treatment; compared reported costs for compliance and model estimates for compliance; and compared plant-by-plant compliance estimates with model-based cost estimates. Based upon the above, EPA concludes that its cost estimates are sufficiently generous to reflect "site-specific" costs and other compliance costs likely to be incurred by the industry.

2. The Impact of Plant Age on the Cost or Feasibility of Retrofitting Control Facilities

The industry challenged both the 1974 and 1976 regulations on the basis that EPA had failed to adequately consider the impact of plant age. In the Phase I decision, the Court held that while EPA had adequately considered the impact of age on waste characteristics and treatability, it had failed to adequately consider the impact of age on the "cost or feasibility of retrofitting" controls.

In the Phase II proceedings, EPA strenuously argued that plant age was not a meaningful criteria in the steel industry because plants are continually rebuilt and modernized. In response to this argument, the Court stated:

> "Were we writing on a clean slate, we might find this argument convincing. But since the facts in this case cannot be properly distinguished from the facts in the earlier case we must reject EPA's contention ... We note, however, that we have not dismissed the EPA's resolution of the retrofit question on the merits. We

merely require that the Agency reexamine the relevance of age specifically as it bears on retrofit." 568 F.2d at 299-300.

In light of these decisions, EPA has throughly examined the impact of plant "age" on the "cost or feasibility" of retrofitting controls. First, in the basic Data Collection Portfolio (DCP) sent to all "steelmaking" operations and about 85% of "forming and finishing" operations, the Agency solicited information on the "age" of plants (including the first year of on-site production and the dates of major rebuilds and modernizations), and the "age" of treatment facilities in place. Next, EPA sent Detailed Data Collection Portfolios (D-DCPs) to a selected number of plants, asking owners of these plants, among other things, for the costs of treatment in place and the portion of those costs attributable to "retrofitting" controls. Finally, the Agency and its engineering consultant evaluated these data to determine whether plant "age" affected the "cost or feasibility of retrofitting" and, if so, whether altered subcategorization or relaxed requirements for "older" plants were warranted.

EPA's evaluation of all available data confirms its earlier conclusion that plant "age" does not significantly affect the "cost or feasibility of retrofitting" pollution controls to existing production facilities. In the first place, plant "age" is not a particularly meaningful criteria in the industry. "Age" is extremely difficult to define. Judging from the first year of on-site production, the industry, as a whole, is "old." But, production facilities are continually rebuilt and modernized, some on periodic "campaign" schedules. Moreover, "campaign" schedules for operations in different subcategories, or even for operations within the same process (e.g., coke batteries) usually are different. Complicating this further is the fact that integrated mills contain many processes of different "ages" with different dates of first on-site production and different rebuild schedules.

Therefore year of first on-site production does not represent the true plant "age." For instance, at the "oldest" (1901) coke facility (based on first year of production), the "oldest" active battery dates from 1968. At several "old" plants (based on first year of production) the "oldest" active batteries range between 1953 and 1973 and the "newest" active batteries date between 1967 and 1979.

The "age" of coke plants, therefore, changes dramatically with the criteria for determining "age." Based on "oldest" active battery, 7.4% of the plants date from 1920 or before; 5.9% date between 1921- 1940; 65.5% date between 1941-1960; and 20.8% date between 1961 and the present. Based on "newest" active battery, 4.4% of the plants date from 1920 or before, 40.2% date between 1941-1960, and the "age" of the majority (55.2%) of the plants is between 1960 and the present. Depending on the criteria selected, the age of a particular cokemaking plant, or the cokemaking industry as a whole, can vary significantly.

In the ironmaking subcategory, the date of first on-site production ranges between 1883 and 1974. However, most blast furnaces undergo major rebuilds every 9 or 10 years. Therefore, the age when determined by the last year of major rebuild would be much younger than that based on the first year of production criteria.

Among most of the other subcategories the situation is similar. Tables III-4 summarize the "age" of plants in the steel industry by subcategory. In each case, the "age" of plants is difficult to define because production facilities are periodically rebuilt and modernized. In many of the remaining subcategories, such as electric arc furnaces, "age" is not relevant because all plants are of the same vintage.

Modernization of production facilities provides an impetus for construction or modernization of treatment facilities. Thus, EPA concludes that because of the continual rebuilding and modernization of production facilities, plant "age" is not a meaningful factor in the steel industry. This conclusion is buttressed by studies commissioned by the industry itself. For example, in Steel and the Environment - A Cost Impact Analysis, which AISI submitted to EPA in its comments on the 1976 rulemaking, Arthur D. Little, Inc. concluded (at page 484) that:

"In the iron and steel industry it is difficult to define the age of a plant because many of the unit operations were installed at different times and also are periodically rebuilt on different schedules. Thus, by definition, the age of steel facilities should offer only limited benefits as a means of categorizing plants for purposes of standard setting or impact analysis."

Despite the difficulty of defining plant "age," EPA did not terminate its analysis of the impact of "age" on the "cost or feasilbilty" of retrofitting controls. On the contrary, the Agency selected determinants of "age" and then analyzed the impact on the "cost or feasibility" of retrofitting.

With regard to the "feasibility" of retrofitting, the evidence is conclusive: Plant "age" does not affect the "ease" or "feasibility" of retrofitting pollution controls. Table III-5 shows that, in all subcategories, some of the "oldest" facilities (based on first year of on-site production) have among the "newest" and most efficient treatment systems. Among coke plants, for example, the oldest by-product plant (024B) had treatment installed as recently as 1977.

With regard to the cost of retrofitting, the impact of plant" age" is more difficult to ascertain. Only 15% of the plants responding to EPA's D-DCPs and reporting retrofitted treatment facilities were able to isolate treatment construction costs attributable to retrofitting. Of those plants that could isolate "retrofit" costs, 73% reported retrofit costs of less than 6% of pollution control costs. On the basis of these survey responses, the Agency concludes that "age" of plants does not have a significant impact on the cost of retrofitting controls on an industry wide basis.

The Agency's examination of the Mahoning Valley plants also supports the conclusion that "age" of plants does not significantly impact the "cost or feasibility" of retrofitting. This examination, which was discussed in regard to "site-specific" costs, showed that, for eight of the oldest plants in the country, the estimated compliance costs did not vary significantly from EPA's model cost estimates.

On the basis of the foregoing, EPA concludes that plant "age" does not significantly affect the "cost or feasibility" of retrofitting controls. However, even assuming that "age" does significantly impact the "cost or feasibility" of retrofitting, EPA concludes that altered subcategorization or relaxed requirements within subcategories for "older" plants are unwarranted. "Older" steel facilities are responsible for as much water pollution as "newer" facilities. Thus, even if it could be shown that plant "age" did affect the "cost or feasibility" of retrofitting controls, EPA would not alter its subcategorization or provide relaxed effluent limitations within subcategories for "older" plants as control of the discharge of pollutants from those plants justify the expenditures of reasonable additional amounts.

3. The Impact of the Regulation on Consumptive Water Loss

In the 1974 BPT and BAT regulation for the steelmaking segment, many of EPA's model treatment systems included partial recycle of wastewaters. Some of these model systems incorporated evaporative cooling towers to insure that the temperature of recycled wastewater did not reach excessive levels for process use.[13] CF&I Steel Corporation, located in Pueblo, Colorado, claimed that cooling through evaporative means would cause additional consumptive water losses which would be inconsistent with state law and would aggravate water scarcity in arid and semi-arid regions of the country. The Court held that to the extent that the regulations were inconsistent with state law, the Supremacy Clause of the U.S. Constitution required that federal law and regulations prevail. The Court agreed with CF&I, however, in holding that EPA had failed to adequately consider the impact of the regulation on water sources in arid and semi-arid regions.

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[13] The treatment models that included evaporative cooling towers were the BPT and BAT models in the cokemaking, blast furnace, steelmaking, vacuum degassing, and continuous casting subcategories. Although there are other available means of temperature equalization (such as lagoons and nonevaporative coolers), only cooling towers were included in treatment models.

The 1976 regulation on the forming and finishing segment also included treatment models with evaporative cooling towers.[14] In its response to CF&I's comments, EPA stated:

> "A means to dissipate heat is frequently a necessity if a recycle system is to be employed. The evaporation of water in cooling towers or from ponds is the most commonly employed means to accomplish this. However, fin-tube heat exchangers can be used to achieve cooling without evaporation of water. Such systems are used in the petroleum processing and electric utility industries.
>
> The Agency also feels that recognition of the evaporation of water in recycle systems (and hence loss of availability to potential downstream users) should be balanced with recognition that evaporation also occurs in once-through systems, when the heated discharge causes evaporation in the stream. This is not an obvious phenomenon, since it occurs downstream of the discharge point, but to the downstream user it is as real as with consumptive in-plant usage. Assuming that the stream eventually gets back to temperature equilibrium with its environment, it will get there primarily by evaporation, i.e., with just as certain a loss of water. Additionally, the use of a recycle system permits lessening the intake flow requirements." 41 FR 12990.

In addition, in its brief the Agency argued that, because of current evaporative losses, the impact of the regulations was not as severe as claimed by CF&I, and that the water scarcity issue was pertinent only in arid and semi-arid regions of the country. The Court, however, held:

> "...Since EPA may have proceeded under a mistaken assumption of fact as to the water loss attributable to the interim final [Phase I] regulations, the matter will be remanded to the Agency for further consideration of whether fin-tube heat exchangers or dry type cooling towers may be employed despite any fouling or scaling problems - assuming that cooling systems of some kind will be employed in order to meet the effluent limitations prescribed in the regulations.
>
> [Also], the Agency may not decline to estimate the water loss due to the interim final regulations as accurately as possible on the grounds that, whatever the cost in water consumption, the specified effluent limitations are justified. In order to insure that the Agency completes a sufficiently specific and definite study of the water consumption problem on remand, the Agency must address the question of how often the various cooling systems will be employed, or present reasons why it cannot make such an assessment."

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[14] The treatment models that included evaporative cooling towers were the BAT models in the hot forming subcategories.

In light of these decisions, EPA has evaluated the "consumptive water loss" issue in the context of this proposed regulation. Several of the underlying model treatment systems include recycle of wastewaters requiring cooling mechanisms. Although cooling can be accomplished by several means (i.e.,lagoons, spray ponds, dry cooling towers), the model treatment systems are based on evaporative cooling towers, which are the most commonly used, least space intensive, and least costly cooling means. In evaluating possible consumptive water losses, however, EPA has also analyzed the effects of several cooling mechanisms other than evaporative cooling towers.

On the average, the steel industry currently uses 6.3 billion gallons of process water per day. Not all of the process water requires cooling. A breakdown of this water usage by subcategory is given in Table III-6. Large amounts of this process water are currently recycled through cooling towers, cooling ponds, and spray ponds as shown below:

Cooling Device	Approximate Evaporation Rate	% Utilization
(1) Cooling Tower (wet-mechanical draft)	2.0%	75%
(2) Cooling ponds	1.7%	20%
(3) Spray ponds	2.0%	5%

Based on the foregoing, EPA estimates that evaporative losses from currently installed recycle/cooling systems, and from once-through discharges of heated water is about 45.2 MGD or 0.7% of total industry process water usage. EPA estimates that nearly 50% of this consumption results from the once-through discharge of heated wastewater and run-of-the-river cooling).

Assuming that the relative utilization rate of the various cooling mechanisms remains the same, EPA estimates that total evaporative water losses will be 51.2 MGD or 0.8% of process water usage at the BPT level, and 81.2 MGD or 1.3% of process water usage at the BAT level when fully implemented.

The important factor for regulatory purposes, however, is not the above gross water losses, but the additional or net water loss attributable to compliance with the proposed regulation. This analysis indicates that net water losses attributable to compliance with the proposed regulation will be 6.0 MGD or 0.1% of process water usage at the BPT level and 36.1 MGD or 0.6% of process water usage at the BAT level. This analysis is detailed for those subcategories where recycle and cooling systems are envisioned in Table III-7 and is summarized below:

	Flow per Day (MGD)	% of Total
Total process water used	6262	100.0
Present water consumption[1]	45.2	0.7
Gross water consumption @ BPT	51.2	0.8
Net water consumption @ BPT	6.1	0.1
Gross water consumption @ BAT[2]	81.2	1.3
Net water consumption @ BAT[2]	36.1	0.6

[1] As of January 1, 1978.

[2] This total includes the water consumed at BPT.

Assuming that cooling towers will be installed by all plants requiring additional cooling (rather than current utilization devices), the net water losses attributable to compliance with the proposed regulation would be 9.2 MGD or 0.1% of total process water usage at the BPT level and 51.5 MGD or 0.8% of process water usage at the BAT level.

In EPA's view, the net water consumption attributable to compliance with the proposed regulation is not significant when compared to the benefits derived from the use of recycle systems. The use of recycle systems at the BAT level will result in a 60% reduction in the total process water usage of the industry. This reduction will prevent 3.8 billion gallons of water per day from being contaminated in steel manufacturing processes. Moreover, recycle systems permit a reduction in the load of pollutants by over 21 million tons per year at the BAT level (including 63,823 tons/year of toxic organic and toxic inorganic pollutants). Finally, it is significant to note that the use of recycle systems is often the least costly means to reduce pollution. On a nation-wide basis, therefore, EPA concludes that the environmental and economic benefits of recycle systems justify the evaporative water losses attributable to cooling mechanisms.

In addition, the Agency evaluated the water consumption issue as it relates to plants in arid and semi-arid regions. The Agency surveyed four major steel plants it considers to be in arid or semi-arid regions of the country. Those plants are as follows.

0196A	CF&I Steel Corporation Pueblo, Colorado
0448A	Kaiser Steel Corporation Fontana, California
0492A	Lone Star Steel Company Lone Star, Texas
0864A	United States Steel Corporation Provo, Utah

The Agency finds that most of the recycle and evaporative cooling systems included in the model treatment systems which are the bases for the proposed limitations and standards have been installed at those plants. Thus, these plants are incurring most, if not all, of the consumptive water losses associated with compliance with the proposed regulation. Hence, the incremental impact of the proposed regulation on water consumption at steel plants located in arid or semi-arid regions is either minimal or nonexistant.

Despite the significant benefits and relatively small evaporative losses from recycle/cooling systems, CF&I of Pueblo, Colorado, claims that recycle/cooling systems will cause severe problems by compounding the water scarcity problems in the arid and semi-arid regions of the country. Therefore, this company suggests that required effluent levels be based on once-through systems or less strigent recycle rates in arid or semi-arid areas.

EPA believes this proposal to be deficient in several respects. First, discharging the heated wastes once through would not conserve a significant amount of water. For example, for an average sized steel mill with a 100 MGD process flow, discharging wastes once through would only conserve 0.4 MGD or 0.4% of the total process water flow, a very small water savings. The savings is small because even in a once-through system, a certain amount of water is evaporated (the evaporation will occur in the receiving body of water as the temperature of the heated wastes approaches the equilibrium temperature of the stream or lake). In this case, the evaportion rate is approximately one-half of the evaporation rate of a cooling tower. However, while a small water savings is achieved, certain disadvantages result, some of which are outlined below:

a. A heated discharge (potentially up to 150°) will be allowed to enter a receiving body of water which may cause localized environmental damage.

b. The once-through system will allow a significantly higher pollutant load to enter the receiving body of water.

c. The once-through system will require additional water to be taken from the water supply to meet the plant's water requirements.

While the use of recycle/cooling systems now result in some additional evaporative water losses in arid and semi-arid regions, EPA believes that here, too, the benefits of recycle systems justify these losses. The Agency considered establishing alternative limitations for facilities located in arid and semi-arid regions, but concluded that alternative limitations are not appropriate. Thus, even if the Agency were to establish a separate subcategory for facilities located in arid or semi-arid regions, the effluent limitations for those plants would be the same as those established for the general subcategory.

TABLE III-1

YOUNGSTOWN SHEET AND TUBE CAPITAL COSTS

Treatment Systems	YS&T	EPA	BATEA Scaled By Flow	BATEA Scaled By Production Rate	Site Costs	BATEA + Site Costs Scaled By Flow	BATEA + Site Costs Scaled By Production Rate
I Electric Weld Tube Brier Hill	1,018,000	985,000	216,000	1,113,000	602,000	818,000	1,715,000
II Blooming Mill Brier Hill	5,390,000	5,141,000	5,114,000	10,645,000	1,150,000	6,264,000	11,795,000
III Blast Furnace Brier Hill	1,576,000*	1,522,000	980,000	1,466,000	1,151,000	2,131,000	2,617,000
IV Seamless Tube Campbell	3,562,000	3,595,000	2,890,000	2,284,000	748,000	3,638,000	3,032,000
V&VA Cold Reduced Mill Campbell	3,817,000	3,523,000	2,466,000	2,771,000	507,000	2,973,000	3,278,000
VI Central Treatment Campbell	25,221,000	25,007,000	28,656,000	30,331,000	10,321,000	38,997,000	40,652,000
VII Coke Plant Campbell	8,973,000	7,300,000	6,822,000	7,691,000	2,074,000	8,896,000*	9,765,000
VIII Galvanized Conduit Struthers	1,179,000	860,000	596,000	493,000	266,000	862,000	759,000
IX Merchant Mill Struthers	3,370,000	3,283,000	5,478,000	3,774,000	1,357,000	6,835,000	5,131,000
TOTAL	54,106,000	51,214,000	53,218,000	60,568,000	18,176,000	71,394,000	78,744,000
HCl Regeneration Campbell	3,470,000						
Blast Furnace Cambpill	2,262,000						
Cold Drawn Bar Brier Hill	84,000						
TOTAL	59,922,000						

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*: Includes 325,000 for blowdown treatment.

TABLE III-2

UNITED STATES STEEL CAPITAL COSTS

Treatment Systems	USS	EPA	BATEA T.M. Scaled by Flow	BATEA T.M. Scaled by Production	Site Costs	BATEA T.M. + Site Costs by Flow	BATEA T.M. + Site Costs by Production
McDonald Plant –	12,800,000	12,131,000	17,612,000	19,787,000	4,400,000	22,012,000	24,187,000
Rolling Mills (Outfall 005)							
Batch & Continuous Pickling (Outfall 006)	550,000	549,000	586,000	586,000	35,000	621,000	603,000
Ohio Plant	13,440,000(1)	11,479,000	5,288,000(2)	5,179,000(2)	6,000,000(2)	11,288,000(2)	11,179,000(2)
Blast Furnace (Outfall 001)							
Rolling Mills (Outfall 003)	5,800,000	5,675,000	3,842,000	8,453,000	2,500,000	6,342,000	10,953,000
Batch Pickling (Outfall 004)	520,000	540,000	441,000	402,000	210,000	651,000	612,000
TOTAL	33,110,000	30,374,000	27,769,000	34,389,000	13,145,000	40,914,000	47,534,000

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(1) Including dismantling of blast furnace.
(2) With base level of treatment.

TABLE III-3

REPUBLIC STEEL CAPITAL COSTS**

Treatment Systems	Republic BPCTCA	BPCTCA Module Scaled By Flow	BPCTCA Module Scaled By Production	BATEA Module Scaled By Flow	BATEA Module Scaled By Production	Site Costs	BPCTCA By Flow + Site Costs	BPCTCA By Production + Site Costs	BATEA By Flow + Site Costs	BATEA By Production + Site Costs
Warren Plant										
Finishing Mills Area	8,000,000	5,879,000	14,387,000	8,765,000	23,943,000	1,294,000	7,458,000	15,681,000	10,059,000	25,237,000
Finishing Mills Pickling	8,800,000	9,610,000	12,243,000	9,678,000	12,330,000	0	9,610,000	12,243,000	9,678,000	12,330,000
Hot Rolling Mills Area	9,700,000	8,518,000	12,543,000	11,826,000	21,075,000	7,645,000	16,163,000	20,188,000	19,471,000	28,720,000
Blast Furnace Area	7,300,000	3,676,000	4,444,000	4,105,000	4,968,000	1,468,000	5,144,000	5,912,000	5,571,000	6,436,000
Coke Plant										
Physical/Chemical	8,000,000	187,000	189,000	1,121,000	937,000	566,000	753,000	755,000	1,681,000	1,503,000
		5,173,000*	5,218,000*	6,106,000*	5,966,000*	566,000	5,739,000*	5,784,000*	6,672,000*	6,532,000*
Biological	8,000,000	414,000	519,000	1,207,000	1,074,000	566,000	1,080,000	1,085,000	1,773,000	1,640,000
		5,500,000*	5,548,000*	6,193,000*	6,103,000*	566,00	6,066,000*	6,144,000*	6,759,000*	6,699,000*
Youngstown Plant										
Poland Avenue	10,899,000	4,501,000	8,010,000	8,742,000	14,633,000	3,314,000	7,815,000	11,324,000	12,056,000	17,947,000
Blast Furnaces	7,900,000	5,388,000	5,417,000	6,023,000	6,054,000	0	5,388,000	5,417,000	6,023,000	6,054,000
Coke Plant										
Physical/Chemical	7,700,000	193,000	296,000	959,000	1,466,000	535,000	728,000	831,000	1,494,000	2,001,000
		5,333,000*	8,164,000*	6,099,000*	9,335,000	535,000	5,868,000*	8,699,000*	6,634,000*	9,870,000
Biological	7,700,000	530,000	812,000	1,054,000	1,680,000	535,000	1,065,000	1,347,000	1,594,000	2,215,000
		5,670,000*	8,680,000*	6,239,000*	9,549,000	535,000	6,205,000*	9,216,000*	6,774,000*	10,084,000
Niles Plant	1,800,000	2,852,000	2,214,000	3,160,000	2,386,000	768,000	3,620,000	2,982,000	3,928,000	3,154,000
TOTAL	70,099,000									
Physical/Chemical*		50,930,000	72,640,000	64,504,000	100,690,000	15,590,000	66,815,000	88,230,000	80,094,000	116,280,000
Biological*		51,594,000	73,486,000	64,731,000	101,041,000	15,590,000	67,479,000	89,076,000	80,321,000	116,631,000

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* : Including Level A Costs.

**: BPCTCA and BATEA costs are based on March, 1975 dollar values.

TABLE III-4

PLANT AGE ANALYSIS[1]
IRON & STEEL INDUSTRY

Subcategory	1919 and before	1920 to 1929	1930 to 1939	1940 to 1949	1950 to 1959	1960 to 1969	1970 and later
A. Cokemaking	33	16	0	6	5	3	3
B. Sintering	0	0	1	7	8	2	3
C. Ironmaking	68	12	8	31	28	11	6
D. Steelmaking							
1. BOF	0	0	0	0	2	21	8
2. Open Hearth	0	0	0	1	4	0	0
3. Electric Arc	0	0	0	1	2	4	5
E. Vacuum Degassing	0	0	0	0	7	21	10
F. Continuous Casting	0	0	0	0	0	23	36
G. Hot Forming							
1. Primary	33	12	11	14	26	11	4
2. Section	67	49	21	29	33	23	14
3. Flat							
a. Strip & Sheet	4	9	11	3	14	12	2
b. Flat Plate	10	1	3	1	2	6	2
4. Pipe & Tube[2]	5	8	11	7	11	4	2

TABLE III-4
PLANT AGE ANALYSIS
IRON & STEEL INDUSTRY
PAGE 2

Subcategory	1919 and before	1920 to 1929	1930 to 1939	1940 to 1949	1950 to 1959	1960 to 1969	1970 and later
H. Scale Removal	0	0	0	4	12	9	4
I. Acid Pickling							
1. Sulfuric Acid	15	16	25	41	43	31	14
2. Hydrochloric Acid	1	1	17	14	17	38	7
3. Combination Acid	6	16	9	22	25	36	11
J. Cold Forming							
1. CR-Recirculation	21	4	11	23	28	32	13
2. CR-Combination	0	0	1	3	5	8	2
3. CR-Direct	0	28	18	5	8	7	1
4. Pipe & Tube	0	4	7	8	23	34	20
K. Alkaline Cleaning	0	4	20	14	41	59	23
L. Hot Coating	5	16	20	26	40	51	12

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(1) Ages based on first year of production.
(2) Does not include the ages for four confidential plants.
Note: Count based on number of individual operations.

TABLE III-5

EXAMPLES OF PLANTS THAT HAVE DEMONSTRATED THE ABILITY TO RETROFIT POLLUTION CONTROL EQUIPMENT BY SUBCATEGORY

Subcategory	Plant Reference Code	Plant Age* (Year)	Treatment Age (Year)
A. Cokemaking	012A	1920	1977
	024A	1916	1953-1977
	024B	1901	1969-1977
	112A	1920	1977
	272	1919	1957-1977
	396A	1906-1955	1972
	432B	1919-1961	1930-1972
	464C	1925-1973	1971
	464E	1914-1970	1914-1977
	584F	1923-1971	1977
	And Others		
B. Sintering	060B	1958	1968
	060F	1957	1975
	112B	1950	1970
	112C	1948	1960
	448A	1943	1971
	548C	1959	1965
	584C	1959	1965
	864A	1944	1962
	868A	1941	1954
	920F	1944	1973
	946A	1939	1972
C. Ironmaking	060B	1942	1958
	112A	1941	1948
	320	1920-1947	1976
	396A	1907-1909	1929
	396C	1903-1905	1929
	426	1958	1979
	432A	1910-1919	1951
	432B	1900-1966	1930
	584C	1956-1961	1965
	584D	1904-1911	1953
	And Others		

TABLE III-5

EXAMPLES OF PLANTS THAT HAVE DEMONSTRATED THE ABILITY TO RETROFIT POLLUTION CONTROL EQUIPMENT BY SUBCATEGORY

PAGE 2

Subcategory	Plant Reference Code	Plant Age* (Year)	Treatment Age (Year)
D. Steelmaking			
1. Basic Oxygen Furnace	432C	1961	1964
	684C	1970	1971
	684F	1966	1976
	724F	1966	1976
2. Open Hearth	060	1952	1970
	112A	1957	1971
	492A	1953	1966
	864A	1944	1962
	748C	1952	1967
3. Electric Furnace	060F	1951	1968
	432C	1959	1964
	528A	1949	1954
	612	1936	1971
E. Vacuum Degassing	88A	1963-1968	1971
	496	1965	1971
F. Continuous Casting	084A	1970-1975	1975
	432A	1969	1974
	476A	1969	1977
	584	1968	1970
	652	1968	1971
	780	1966-1975	1975
G. Hot Forming			
1. Hot Forming - Primary	020B	1948	1971
	060D	1910	1959
	060I	1941	1958
	088D	1959	1971
	112	1907	1979
	112A	1930	1970
	112B	1928	1970
	176	1917	1965
	188A	1959	1970
	188B	1940	1946
	248C	1962	1975
	320	1936	1952
	And Others		

TABLE III-5
EXAMPLES OF PLANTS THAT HAVE DEMONSTRATED THE ABILITY TO RETROFIT POLLUTION CONTROL EQUIPMENT BY SUBCATEGORY
PAGE 3

Subcategory	Plant Reference Code	Plant Age* (Year)	Treatment Age (Year)
2. Hot Forming - Section	060C	1913	1920-1975
	060F	1942	1965
	060I	1956	1958
	060K	1920	1955
	088D	1962	1971
	112	1907	1954-1979
	112A	1937	1971-1977
	112F	1922	1947-1978
	136B	1908	1959-1969
	316	1959	1966
3. Hot Forming - Flat			
a. Plate	112C	1902	1964
	424	1970	1971-1978
	448A	1943	1948
	496	1918	1948-1977
	860B	1936	1967
b. Hot Strip & Sheet	020B	1953	1971
	396D	1960	1970
	432A	1957	1974
	476A	1915	1977
	684F	1937	1969
	856D	1938	1980
	856P	1929	1966
4. Pipe and Tube	060C	1913	1948
	060F	1950	1971
	060R	1930-1947	1961
	432A	1957-1958	1974
	476A	1930	1977
	548A	1945-1960	1969
	652A	1954	1962
	728	1929	1952
	856N	1930	1961
	856Q	1930	1963
	And Others		

TABLE III-5
EXAMPLES OF PLANTS THAT HAVE DEMONSTRATED THE ABILITY TO RETROFIT POLLUTION CONTROL EQUIPMENT BY SUBCATEGORY
PAGE 4

Subcategory	Plant Reference Code	Plant Age* (Year)	Treatment Age (Year)
H. Scale Removal	060I	1970	1972
	088A	1962	1969
	256L	1962	1969
	424	1971	1978
	284A	1957	1971
	176	1941	1965
	256K	1956	1971
	248B	1950	1978
I. Acid Pickling			
1. Sulfuric Acid	020B	1954	1974
	048F	1944	1969
	060D	1957	1968
	060M	1970	1977
	088A	1936	1969
	088D	1962	1971
	112	1922	1977
	112C	1926	1977
	256F	1953	1975
	384A	1958	1964
	And Others		
2. Hydrochloric Acid	020C	1946	1977
	112B	1936	1971
	176	1961	1956
	320	1936	1955
	384A	1932	1970
	396D	1967	1969
	432C	1952	1964
	448A	1954	1970
	580A	1962	1967
	And Others		
3. Combination Acid	020B	1947	1974
	088A	1952	1969
	112A	1926	1977
	112H	1940	1951
	256F	1953	1975
	284A	1957	1971
	584D	1940	1970
	860F	1962	1977
	And Others		

TABLE III-5
EXAMPLES OF PLANTS THAT HAVE DEMONSTRATED THE ABILITY TO RETROFIT POLLUTION CONTROL EQUIPMENT BY SUBCATEGORY
PAGE 5

Subcategory	Plant Reference Code	Plant Age* (Year)	Treatment Age (Year)
J. Cold Forming			
	020C	1951	1975
	060	1936	1967
	112A	1947	1971
	112B	1936	1971
	176	1921	1963
	396D	1938	1959
	432B	1937	1966
	448A	1952	1969
	584A	1948	1971
	684D	1939	1970
	And Others		
K. Alkaline Cleaning	112A	1936	1971-1977
	112I	1927	1950-1977
	240B	1938	1968
	256N	1956	1973
	384A	1968	1970
	432A	1940	1970
	448A	1959	1969
	476A	1960	1977
	548A	1957	1967
	580A	1962	1967
	And Others		
L. Hot Coating	112B	1962	1971
	112G	1922	1973
	384A	1968	1970
	448A	1967	1970
	460A	1932	1968
	476A	1930	1977
	492A	1962	1976
	580A	1962	1967
	584C	1956	1965
	640	1936	1961

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* Where ranges of ages are listed, this shows that these are multiple facilities on site that vary in age as indicated.

TABLE III-6

WATER USAGE IN THE STEEL INDUSTRY

Subcategory	Total Process Water Usage (MGD)	Water Recycled Over Cooling Systems at BPT (MGD)	Water Recycled Over Cooling Systems at BAT (MGD)
A. Cokemaking	36.9	32.4(1)	41.98(1)
B. Sintering	122.6	0	0
C. Ironmaking	1036.8	996.3	1030.1
D. Steelmaking	284.4	0	0
E. Vacuum Degassing	57.1	56.1	56.1
F. Continuous Casting	238.0	229.2	236.3
G. Hot Forming	4188.0	0	2502.5
H. Scale Removal	0.9	0	0
I. Pickling	172.7	0	0
J. Cold Forming	87.3	0	0
K. Alkaline Cleaning	2.9	0	0
L. Hot Coating	34.7	0	0
	6262.3	1314.0	3867.0

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(1) Flow not included as part of the total process water flow.

TABLE III-7

CONSUMPTIVE USE OF WATER (BY EVAPORATION IN COOLING SYSTEMS) IN THE STEEL INDUSTRY(1)

Subcategory	Present Water Consumption (MGD)	Additional Consumption at BPT over Present (MGD)	Water Consumption Anticipated at BPT (MGD)	Additional Consumption at BAT over Present (MGD)	Water Consumption Anticipated at BAT (MGD)
A. Cokemaking	0.69	0.16	0.85	0.40	1.09
C. Ironmaking	11.90	5.40	17.30	19.30	31.20
E. Vacuum Degassing	0.83	0.13	0.96	0.13	0.96
F. Continuous Casting	3.55	0.37	3.92	0.37	3.92
G. Hot Forming	28.20	0	28.20	15.85	44.05
	45.17	6.06	51.23	36.05	81.22

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(1) Only those subcategories which utilize recycle and cooling systems are included in this analysis.

SECTION IV

INDUSTRY SUBCATEGORIZATION

To develop the proposed regulation it was necessary for the Agency to determine whether different effluent limitations and standards should be developed for distinct segments or subcategories of the steel industry. The EPA subcategorization of the industry included an examination of the same factors and rationale described in the Agency's previous studies. Those factors are:

1. Manufacturing processes and equipment
2. Raw materials
3. Final products
4. Wastewater characteristics
5. Wastewater treatment methods
6. Size and age of facilities
7. Geographic location
8. Process water usage and discharge rates
9. Costs and economic impacts

For this regulation, the Agency has adopted a revised subcategorization of the industry to more accurately reflect production operations and to simplify the use of the regulation. The Agency found that manufacturing process is the most significant factor and divided the industry into 12 main process subcategories on this basis. Section IV of each subcategory report contains a detailed discussion of the factors considered and the rationale for selecting and subdividing the subcategories. The Agency determined that process based subcategorization is warranted in many cases because the wastewaters of the various processes contain different pollutants, requiring treatment by different control systems (e.g., phenol by biological systems in cokemaking). However, in some cases, the wastewaters of different processes were found to contain similar characteristics. In those instances, the Agency determined that subcategorization was appropriate because the process water usage and discharge flow rates varied widely thus affecting estimates of treatment system costs. The twelve subcategories of the steel industry are as follows:

A. Cokemaking
B. Sintering
C. Ironmaking
D. Steelmaking
E. Vacuum Degassing
F. Continuous Casting
G. Hot Forming
H. Scale Removal
I. Acid Pickling
J. Cold Forming
K. Alkaline Cleaning
L. Hot Coatings

The subcategories of the steel industry are defined below. Also discussed are any subdivisions within the main subcategories and the rationale for the subdivision and segmentation.

Subcategory A: Cokemaking

Cokemaking operations involve the production of coke in by-product or beehive ovens. The production of metallurgical coke is an essential part of the steel industry, since coke is one of the basic raw materials necessary for the operation of ironmaking blast furnaces.

Extreme variations exist in the quantity and quality of waste generated between the old beehive ovens and the newer by-product ovens. In order to prepare effluent limitations that would adequately reflect these variations, a subdivision of the cokemaking subcategory was necessary. The first subdivision is by-product cokemaking, a method employed by 99 percent of the coke plants in the U.S. In by-product ovens, coke oven gas, light oil, ammonium sulfate and sodium phenolate are recovered rather than allowed to escape to the atmosphere. Beehive cokemaking is the other subdivision in the cokemaking subcategory. This process is only found in one percent of the U.S. cokemaking operations. In beehive ovens no effort is made to recover volatile material generated by the process.

Subcategory B: Sintering

Sintering operations involve the production of an agglomerate which is then reused as a feed material in iron and steelmaking processes. This agglomerate or "sinter" is made up of large quantities of particulate matter (fines, mill scale, flue dust) which have been generated by blast furnaces, open hearth furnaces, and basic oxygen furnaces, and scale recovered from hot forming operations.

Wastewaters are generated in sintering operations as a result of the scrubbing of dusts and gases produced in the sintering process. The quenching and cooling of the sinter generates additional wastewater. Various methods are used to control water pollution in sintering operations. However, the Agency determined that the slight variation in quantity and quality of wastewater generated did not warrant further subdivision of this subcategory.

Subcategory C: Ironmaking

Ironmaking operations involve the conversion of iron bearing materials, limestone, and coke into molten iron in a reducing atmosphere in a tall cylindrical furnace. The gases produced as a result of this combustion are a valuable heat source but require cleaning prior to reuse. Blast furnace wastewaters are generated as a result of the scrubbing and cooling of these effluent gases. Both pig-iron and ferromanganese iron can be produced in blast furnace operations. Because the wastewaters produced at these two types of operations vary significantly, different BPT limitations are being proposed. However, BAT, NSPS, PSES and PSNS are proposed only for ironmaking blast furnaces since no ferromanganese furnaces are in operation or scheduled for operation and ferroalloy production has shifted to electric furnaces.

Subcategory D: Steelmaking

Steelmaking operations involve the production of steel in basic oxygen, open hearth, and electric arc furnaces. These furnaces receive iron produced in blast furnaces along with scrap metal and fluxing materials. During steelmaking, large quantities of fume, smoke, and waste gases are generated which require cleaning prior to emission to the atmosphere. Steelmaking wastewaters are generated as a result of these gas cleaning operations.

Each of the three types of furnaces operates differently. These differences result in significant variations in waste loads generated. In order to develop effluent limitations that would adequately reflect these variations, the Agency determined that a subdivision of the steelmaking subcategory was necessary. The steelmaking subcategory has been divided into three subdivisions as follows: basic oxygen furnace; open hearth furnace; and electric arc furnace. However, the Agency determined that further segmentation of each subdivision was appropriate because of the different of methods used to treat furnace gases.

Three different scrubbing systems, each of which could result in a wastewater discharge, are presently used to clean waste gases from basic oxygen furnaces: semi-wet; wet-open combustion; and wet-suppressed combustion. Semi-wet systems are characterized by wastewaters containing relatively small quantities of particulate matter having a large particle size. Wet systems result in much higher raw wastewater loading due to the increased amount of water used. In an open combustion system, 90 percent of the particulates are of a submicron size, because combustion is more complete. By comparison, suppressed combustion systems generate larger particles. Only 30-40 percent are of submicron size. However, because heavier particulate matter remains in the furnace, the suspended solids concentration in the wastewater of a suppressed combustion system is much lower.

Two different scrubbing systems resulting in a wastewater discharge are presently used in the open hearth furnace and electric arc furnace subcategories. These systems are the semi-wet and the wet systems, and they are very similar to the methods used to clean basic oxygen furnace waste gases. In the semi-wet system, there is only brief contact between water and particle laden gases. Therefore, the concentration of particles in the wastewater is very low and the wastewater flow rate is relatively small. The purpose of the water is not to scrub or clean the gas but to condition the gas for the electrostratic precipitator or bag house which is the principle device for removal of solids in the semi-wet systems. By comparision, the wet scrubber system is designed to remove all of the particulate matter from the gases. Therefore, both the wastewater flow rate and the concentration of particulate matter are higher in the wet scrubbing system.

Subcategory E: Vacuum Degassing

Vacuum degassing is the process whereby molten steel is subjected to a vacuum in order to remove gaseous impurities. It is advantageous to remove hydrogen, nitrogen, and oxygen from the molten steel as these gases impart undesirable qualities to the finished steel product. The particle laden steam, coming from the steam ejectors used to produce the vaccum, is condensed in barometric condensers thus producing a wastewater requiring treatment. The venturi action in the ejector throat and the condensation of the steam that combine to produce the vaccum.

The industry uses various types of degassers and degasses steels containing a variety of different components. However, the Agency has determined these variations do not affect the quantity or quality of wastewaters produced in the vacuum degassing operations. Accordingly, the Agency determined that further subdivision of this subcategory was not warranted.

Subcategory F: Continuous Casting

The continuous casting process takes molten steel from basic oxygen, open hearth, or electric arc furnaces, and continuously casts the molten steel into a water cooled copper mold resulting in a semi-finished product. After leaving the copper mold, the semi-solidified steel is sprayed with water to further cool and solidify it. In addition to cooling, the water sprays also serve to remove scale and other impurities from the steel's surface. The water which directly cools the steel is the particle laden wastewater which must be treated prior to discharge.

Although there are three varieties of continuous casters in use, they only differ in physical orientation. When the Agency analyzed these and other factors relating to the continuous casting subcategory, it determined that there were no significant variations in the quantity or quality of wastewaters produced. Therefore, the Agency determined that further subdivision of the continuous casting subcategory was unwarranted.

Subcategory G: Hot Forming

Hot forming is the steel forming process in which hot steel is transformed in size and shape through a series of forming steps to ultimately produce semi-finished and finished steel products. Feed materials may be ingots, continuous caster billets, or blooms and slabs from a primary hot forming mill (as feed to hot forming section or hot forming flat mills). The steel products consist of many types of cross-sections, sizes and lengths. Four different types of hot forming mills are required to produce the many types of hot formed steel products. The four types of mills (primary, section, flat, and pipe and tube) are the basis for the principal segments of the hot forming subcategory. Variations in flow rates and configuration between these segments were the most important factors in making this subdivision. Further subdivision has found to be necessary because of product shape, type of steel, process used, and mill size.

Wastewaters result from several sources in hot forming operations. The hot steel is reduced in size by a number of rolling steps where contact cooling water is continuously sprayed over the rolls and hot steel product to cool the steel rolls and the flush away scale as it is broken off from the surface. Scarfing is used at some mills to remove imperfections in order to improve the quality of steel surfaces. Scarfing generates large quantities of fume, smoke, and waste gases which require scrubbing. The scrubbing of these fumes generates additional wastewater.

The Agency found that variations exist in the quantity of wastewaters generated in the four segments of the hot forming subcategory. In order to develop effluent limitations that would adequately reflect these variations, the Agency determined that further division of the hot forming subcategory was necessary.

The primary mill subdivision has been split into two segments: (1) carbon and specialty without scarfing, and (2) carbon and specialty with scarfing. The use of scarfing equipment results in an additional applied process flow of 1100 gal/ton, making the division necessary.

The section mill subdivisions has also been separated into two segments, carbon and specialty steels. Carbon section mills use on the average, 1900 gal/ton more water than do specialty mills. Based on this factor the Agency determined that it was appropriate to further divide the section mill segment.

The flat mill subdivision has been split into three segments: (1) hot strip and sheet (both carbon and specialty), (2) plate (carbon) and (3) plate (specialty). As in the section mills, carbon and specialty plate operations differ significantly in several areas. Carbon flat plate operations use 1900 gal/ton more water than do specialty flat plate operations. Also, carbon plate mills produce approximately three times as much steel per day as do specialty plate mills. While no differences were noted between carbon and specialty hot strip and sheet operations, hot strip operations in general require 4900 gal/ton more water than do plate operations. That difference resulted in the hot strip and sheet division in the hot forming flat segment.

The Agency determined that no further segmentation of the hot worked pipe and tube subdivision is necessary.

Subcategory H: Scale Removal

Scale removal is the operation in which specialty steel products are processed in molten salt solutions. Two types of scale removal operations are in use: kolene and hydride. The kolene process uses highly oxidizing salt baths which react far more aggressively with the scale than with base metal. This chemical action causes surface scale to crack so that subsequent pickling operations are more effective in removing the scale. Hydride descaling depends upon the strong reducing properties of sodium hydride. During that operation most scale forming oxides are reduced to base metal.

Flow rates and wastewater characteristics differ between the kolene and hydride scale removal operations. Hydride operations can discharge quantities of cyanide not contained in kolene wastewater. Kolene operations discharge large amounts of hexavalent chromium, which are not usually found in hydride wastewaters. In order to develop effluent limitations that would adequately reflect these variations, the Agency determined that subdivision of the scale removal subcategory into kolene and hydride segments was appropriate.

Subcategory I: Acid Pickling

Acid pickling is the process of chemically removing oxides and scale from the surface of the steel by the action of water solutions of inorganic acids. The three major wastewater sources associated with pickling are spent pickle liquor, rinse water, and the water used to scrub acid vapors and mists. These wastewaters contain free acids and ferrous salts in addition to other organic and inorganic impurities. Most carbon steels are pickled in sulfuric or hydrochloric acids. Most stainless and alloy steels are pickled in a mixture of nitric and hydrofluoric acids. Since wastewater characteristics are dependent on the acid used, the Agency has decided to establish three primary segments of this subcategory.

The first subdivision, sulfuric acid pickling, was further separated into four segments based upon the method used to treat the wastewaters produced. The acid recovery method crystallizes the iron salts, predominately ferrous sulfate, out of the pickling wastewater. The sulfuric acid which remains may then be strengthened to its original concentration with make-up acid. This solution is then ready for reuse. Acid recovery is practiced with both batch and continuous operations. Zero discharge can be achieved with acid recovery for batch operations. Continuous operations usually have a discharge.

Another method of treating waste sulfuric acid wastewater is by neutralization and sedimentation of batch and continuous operation wastewaters. Because the respective flows are significantly different the Agency decided to establish separate subdivisions for batch and continuous neutralization operations.

The hydrochloric acid subdivision was separated into three segments. The first segment is the acid regeneration method used for continuous processes (it is not cost effective to install a regeneration system for batch operations). In this method, the pickling reaction is reversed. Ferrous chloride is hydrolyzed to an iron oxide by-product and HCl gas. This step is followed by the absorption of the gas and reformation of liquid hydrochloric acid. The liquid hydrochloric acid can then be reused for pickling. Acid recovery differs from acid regeneration in that the unreacted sulfuric acid is merely recovered as opposed to being chemically regenerated.

As with sulfuric acid, hydrochloric acid wastewaters can also be treated through neutralization. Again the quantities and qualities of the waste streams differ significantly between continuous and batch neutralization systems. Based upon these differences, the Agency decided to establish two other segments of the hydrochloric acid pickling subdivision: batch and continuous neutralization.

The combination acid subdivision has been separated into two segments, batch and continuous neutralization systems. The continuous operations normally discharge much greater quantities of wastewater than do the batch operations and the Agency determined that further subdivision was appropriate based on that difference.

In all three subdivisions, sulfuric acid, hydrochloric acid, and combination acid, some operations use fume scrubbing systems while others do not. Allowances, at the BPT level, for higher water flow were made for operations with scrubbers.

Subcategory J: Cold Forming

Cold forming operations transform steel of various configurations (i.e., bar, slab, sheet) to the final configuration desired. The cold forming subcategory is separated into two subdivisions: cold rolling and cold working pipe and tube. The Agency concluded that subdivision was appropriate because of the differences between equipment used to form flat sheets and tubular shapes.

Cold rolling is the operation which passes unheated metal through a pair of rolls for the purpose of reducing its thickness, producing a smooth dense surface and developing controlled mechanical properties in the metal. An oil-water emulsion lubricant is sprayed on the material prior to its entering the rolls of a cold rolling mill, and the material is coated with oil prior to recoiling. This oil prevents rust while the material is in transit or in storage this oil must be removed before the material can be further processed or formed. Oil from the oil water emulsion lubricant is the major pollutant load in wastewaters resulting from this operation.

In cold rolling operations, the main element that affects the segmentation of this subdivision is the variety of oil application methods used. The methods are direct application, recirculation, and combinations. Because the recycle rate if any is dependent upon the oil application system chosen, flow rates vary for the three systems.

This difference in flow rate, and hence the pollutant load allocation, makes further segmentation of the cold rolling segment appropriate.

Pipe and tube operations form the other subdivision of the cold forming subcategory. In pipe and tube operations (cold worked) cold flat steel strips are formed into hollow cylindrical products. Wastewaters are generated as a result of continuous flushing with soluble oil lubrication solutions. There are a variety of methods of cold forming pipes and tubes, there are significant differences in the quantity or quality of wastewaters generated by these methods. Therefore, the Agency determined that further segmentation of the pipe and tube subdivision was warranted.

Subcategory K: Alkaline Cleaning

Alkaline cleaning baths are used to remove mineral and animal fats and oils from steel. The cleaning baths used are not very aggressive and therefore do not generate many pollutants. The alkaline cleaning solution is usually a dispersion of chemicals such as carbonates, alkaline silicates, and phosphates in water. The cleaning bath itself and the rinse water used are the two sources of wastewaters in the alkaline cleaning process. Although both continuous and batch operations are employed industry-wide, the Agency did not find a significant difference in the quality and quantity of wastewaters generated between the two types of processes. Therefore, the Agency determined that no further subdivision of the alkaline cleaning subcategory was warranted.

Subcategory L: Hot Coatings

Hot coating processes involve the immersion of clean steel into baths of molten metal for the purpose of depositing a thin layer of metal onto the steel surface. These metal coatings can impart such desirable qualities as corrosion resistance or a decorative appearance to the steel. Hot coating processes can be carried out on either a continuous or batch basis. The physical configuration of the product being coated usually determines the method of coating to be used.

The hot coating subcategory has been divided into three subdivisions. This division is based on the type of coating used. Galvanizing is basically a zinc coating operation. Terne coating consists of a lead and tin application in a ratio of five or six parts lead to one part tin. Other metal coatings can include aluminum, cadmium, hot dipped tin, or mixtures of metals. These three different types of coatings generate different pollutants due to the variety of metals used. For this reason they have been designated as subdivisions of the hot coating subcategory.

These subdivisions have been further divided. In the galvanizing (zinc coating) subdivision, a significant difference was found between flow rates for processing strips and sheets and flow rates for processing wire products. On a gallon per ton basis, the wire product flow rates are as much as four times greater than the strip and sheet rates. This increased flow rate is a result of the physical configuration of the wire products which have a much greater surface area to tonnage ratio than do strips or sheets. Since the surface area is being coated, the volume of the coating and rinse and, hence the wastewater volume, will be much greater for wire products.

In the terne coating subdivision, no further segmentation due to product is necessary. Strips and sheets are normally the only shapes which are be terne coated. Terne coating provides corrosion resistance. A major portion of all terne coated material is used in the automobile industry.

The subdivision for other coatings has also been separated into two semgents. The same rationale applies in this instance. The surface area to tonnage ratio is much greater for wire products than it is for sheets or strips. Therefore, the volume of wastewaters generated per ton of steel coated is also much greater for wire products than it is for sheets or strips. For this reason, the Agency determined that further segmentation of this subdivision is appropriate.

VOLUME I

SECTION V

SELECTION OF REGULATED POLLUTANTS

Introduction

Three types of pollutants were considered for regulation in the steel industry: conventional, nonconventional and toxic pollutants. Sampling and subsequent analysis of process wastewaters were carried out industry-wide. Average wastewater concentrations of each pollutant were determined by subcategory, and these concentrations in conjunction with the waste loading, formed the basis for determining whether a particular pollutant is proposed for regulation.

Development of Regulated Pollutants

The concentration data were reviewed for 141 pollutants; 130 toxic, 8 nontoxic nonconventional, and 3 conventional. These values ranged from "not detected" to 71,000 mg/l (ppm). Each concentration value was reviewed individually and the respective pollutant was assigned to one of four categories.

1. Not Detected - Reserved for any pollutant which was not detected during industry-wide plant sampling.

2. Unique Occurrence - Pollutants detected at levels of 0.010 mg/l (10 ppb) or less in industry-wide plant sampling.

3. Not Treatable - Pollutants which were detected at levels greater than 10 ppb yet less than the treatability level determined for that pollutant and discussed in Section VI.

4. Regulation Considered - Any pollutant detected at a level greater than the corresponding treatability level outlined in Section VI was designated as being considered for regulation.

The results of the categorization are presented in Table V-1. Of the 141 pollutants initially considered, 58 (48 toxic, 10 others) have been considered for regulation. In order to further analyze the source of these pollutants, their presence by subcategory was tabulated. Table V-2 lists pollutants appearing in the twelve subcategories at levels greater than treatability. These 58 pollutants are reviewed in a report entitled "Summary of Pollutants Detected in the Steel Industry". The physical properties, toxic effects in humans and aquatic life and behavior in POTWs of the various pollutants are discussed in the following material. Particular weight has been given to documents generated by the EPA Criteria and Standards Division and Monitoring and Data Support Division.

Acrylonitrile (3). Acrylonitrile ($CH_2=CHCN$) is an explosive flammable liquid having a normal boiling point of 77°C and a vapor pressure of 80 mmHg at 20°C. It is miscible with most organic solvents. It is manufactured by the reaction of propylene with ammonia and oxygen in the presence of a catalyst. Annual U.S. production is eight hundred thousand tons.

The major use of acrylonitrile is in the manufacture of copolymers for the production of acrylic and modacrylic fibers. It is also used in the plastics, surface coatings, and adhesives industries.

The acute toxicity of acrylonitrile is well known. The compound appears to exert part of its toxic effect through the release of inorganic cyanide. Inhalation has been reported to be the major route of exposure in lethal cases of acrylonitrile poisoning. Toxic manifestations of acrylonitrile inhalation include disorders of the central nervous system and chronic upper respiratory tract irritation. The next most likely route of exposure is dermal. Dermatologic conditions include contact allergic dermatitis, occupational eczema and toxodermia. The least likely route of exposure of acrylonitrile is through ingestion. Ingestion usually occurs through exposure to water or aquatic life containing acrylonitrile or exposure to food products packaged in materials which leach acrylonitrile to the food.

There is suggestive evidence that acrylonitrile is carcinogenic to humans and animals. NIOSH 1978 states, "...acrylonitrile must be handled in the workplace as a suspect human carcinogen." Laboratory rats which had acrylonitrile administered to them through inhalation and drinking water developed central nervous system tumors and zymbal gland carcinomas not evident in the control animals. Numerous reports have been made of the embryotoxicity, mutagenicity, and teratogenicity of acrylonitrile in laboratory animals.

For the maximum protection of human health from the potential carcinogenic effects of exposure to acrylonitrile through ingestion of water and contaminated aquatic organisms, the ambient water concentration is zero. Concentrations of acrylonitrile estimated to result in additional lifetime cancer risk at levels of 10^{-7}, 10^{-6} and 10^{-5} are 5.79×10^{-6} mg/l, 5.79×10^{-5} mg/l and 5.79×10^{-4} mg/l, resepctively. If contaminated aquatic organisms alone are consumed excluding the consumption of water, the water concentration should be less than 6.52×10^{-3} mg/l to keep the lifetime cancer risk below 10^{-5}. Limited acute and chronic toxicity data for fresh water aquatic life show that adverse effects occur at concentrations higher than those cited for human health risks.

Some studies have been reported regarding the behavior of acrylonitrile in POTW. Biochemical oxidation of acrylonitrile under laboratory conditions at concentrations of 86-162 mg/l, produced 0, 2, and 56 percent degradation in 5, 10, and 20 days, respectively, using unacclimated seed cultures. Degradation of 72 percent was produced in 10 days using acclimated seed cultures. Based on these data and general conclusions relating molecular structure to biochemical oxidation, it is expected that acrylonitrile will be biochemically oxidized to a lesser extent than domestic sewage by biological treatment in POTW. Other reports suggest that acrylonitrile entering an activated sludge process in concentrations of 50 ppm or greater, may inhibit certain bacterial processes such as nitrification.

Benzene (4). Benzene (C_6H_6) is a clear, colorless, liquid obtained mainly from petroleum feedstocks by several different processes. Some is recovered from light oil obtained from coal carbonization gases. It boils at 80°C and has a vapor pressure of 100 mm Hg at 26°C. It is slightly soluble in water (1.8 g/l at 25°C) and it disolves in hydrocarbon solvents. Annual U.S. production is three to four million tons.

Most of the benzene used in the U.S. goes into chemical manufacture. About half of that is converted to ethylbenzene which is used to make styrene. Some benzene is used in motor fuels.

Benzene is harmful to human health according to numerous published studies. Most studies relate effects of inhaled benzene vapors. These effects include nausea, loss of muscle coordination, and excitement, followed by depression and coma. Death is usually the result of respiratory or cardiac failure. Two specific blood disorders are related to benzene exposure. One of these, acute myelogenous leukemia, represents a carcinogenic effect of benzene. However, most human exposure data are based on exposure in occupationed settings and benzene carcinogenisis is not considered to be firmly established.

Oral administration of benzene to laboratory animals produced leukopenia, a reduction in number of leukocytes in the blood. Subcutaneous injection of benzene-oil solutions has produced suggestive, but not conclusive, evidence of benzene carcinogenisis.

Benzene demonstrated teratogenic effects in laboratory animals, and mutagenic effects in humans and other animals.

For maximum protection of human health from the potential carcinogenic effects of exposure to benzene through ingestion of water and contaminated aquatic organisms, the ambient water concentration is zero. Concentrations of benzene estimated to result in additional lifetime cancer risk at levels of 10^{-7}, 10^{-6}, and 10^{-5} are 8×10^{-5} mg/l, 8×10^{-4} mg/l, and 8×10^{-3} mg/l, respectively. If contaminated aquatic organisms alone are consumed, excluding the consumption of water, the water concentration should be less than 0.478 mg/l to keep the lifetime cancer risk below 10^{-5}. Available data show that adverse effects on aquatic life occur at concentrations higher than those cited for human health risks.

Some studies have been reported regarding the behavior of benzene in POTW. Biochemical oxidation of benzene under laboratory conditions, at concentrations of 3 to 10 mg/l, produced 24, 27, 24, and 29 percent degradation in 5, 10, 15, and 20 days, respectively, using unacclimated seed cultures in fresh water. Degradation of 58, 67, 76, and 80 percent was produced in the same time periods using acclimated seed cultures. Other studies produced similar results. Based on these data and general conclusions relating molecular structure to biochemical oxidation, it is expected that benzene will be biochemically oxidized to a lesser extent than domestic sewage by biological treatment in POTW. Other reports indicate that most benzene entering a POTW is removed to the sludge and that influent concentrations of 1 g/l inhibit sludge digestion. An EPA study of the fate of priority pollutants in POTW reveals removal efficiencies of 70 to 98 percent for three POTW where influent benzene levels were 5 x 10^{-3} to 143 x 10^{-3} mg/l. Four other POTW samples had influent benzene concentrations of 1 or 2 x 10^{-3} mg/l and removals appeared indeterminate because of the limits of quantification for analyses. There is no information about possible effects of benzene on crops grown in soils amended with sludge containing benzene.

Hexachlorobenzene (9). Hexachlorobenzene (C_6Cl_6) is a nonflammable crystalline substance which is virtually insoluble in water. However, it is soluble in benzene, chloroform, and ether. Hexachlorobenzene (HCB) has a density of 2.044 g/ml. It melts at 231°C and boils at 323-326°C. Commercial production of HCB in the U.S. was discontinued in 1976, though it is still generated as a by-product of other chemical operations. In 1972, an estimated 2425 tons of HCB were produced in this way.

Hexachlorobenzene is used as a fungicide to control fungal diseases in cereal grains. The main agricultural use of HCB is on wheat seed intended soley for planting. HCB has been used as an impurity in other pesticides. It is used in industry as a plasticizer for polyvinyl chloride as well as a flame retardant. HCB is also used as a starting material for the production of pentachlorophenol which is marketed as a wood preservative.

Hexachlorobenzene can be harmful to human health as was seen in Turkey from 1955-1959. Wheat that had been treated with HCB in preparation for planting was consumed as food. Those people affected by HCB developed cutanea tarda porphyria, the symptoms of which included blistering and epidermolysis of the exposed parts of the body, particularly the face and the hands. These symptoms disappeared after consumption of HCB contaminated bread was discontinued. However, the HCB which was stored in body fat contaminated maternal milk. As a result of this, at least 95 percent of the infants feeding on this milk died. The fact that HCB remains stored in body fat after exposure has ended presents an additional problem. Weight loss may result in a dramatic redistribution of HCB contained in fatty tissue. If the stored levels of HCB are high, adverse effects might ensue.

Limited testing suggests that hexachlorobenzene is not teratogenic or mutagenic. However, two animal studies have been conducted which indicate that HCB is a carcinogen. HCB appears to have multipotential carcinogenic activity; the incidence of hepatomas, haemangioendotheliomas and thyroid adenomas was significantly increased in animals exposed to HCB by comparison to control animals.

For maximum protection of human health from the potential carcinogenic effects of exposure to hexachlorobenzene through ingestion of water and contaminated aquatic organisms, the ambient water concentration is zero. Concentrations of HCB estimated to result in additional lifetime cancer risk at levels of 10^{-7}, 10^{-6}, and 10^{-5} are 7.2 x 10^{-8} mg/l, 7.2 x 10^{-6}mg/l, and 7.2 x 10^{-6} mg/l, respectively. If contaminated aquatic organisms alone are consumed, excluding the consumption of water, the water concentration should be less than 7.4 x 10^{-6} mg/l keep the increased lifetime cancer risk below 10^{-5}. Available data show that adverse effects on aquatic life occur at concentrations higher than those cited for human health risks.

No detailed study of hexachlorobenzene behavior in POTW is available. However, general observations relating molecular structure to ease of degradation have been developed for all of the organic priority pollutants. The conclusion reached by study of the limited data is that biological treatment produces little or no degradation of hexachlorobenzene. No evidence is available for drawing conclusions regarding its possible toxic or inhibitory effect on POTW operations.

1,1,1-Trichloroethane(11). 1,1,1-Trichloroethane is one of the two possible trichlorethanes. It is manufactured by hydrochlorinating vinyl chloride to 1,1-dichloroethane which is then chlorinated to the desired product. 1,1,1-Trichloroethane is a liquid at room temperature with a vapor pressure of 96 mm Hg at 20°C and a boiling point of 74°C. Its formula is CCl_3CH_3. It is slightly soluble in water (0.48 g/l) and is very soluble in organic solvents. U.S. annual production is greater than one-third of a million tons.

1,1,1-Trichloroethane is used as an industrial solvent and degreasing agent.

Most human toxicity data for 1,1,1-trichloroethane relates to inhalation and dermal exposure routes. Limited data are available for determining toxicity of ingested 1,1,1-trichloroethane, and those data are all for the compound itself not solutions in water. No data are available regarding its toxicity to fish and aquatic organisms. For the protection of human health from the toxic properties of 1,1,1-trichloroethane ingested through the consumption of water and fish, the ambient water criterion is 18.4 mg/l. If aquatic organisms alone are consumed, the water concentration should be less than 1030 mg/l. Available data show that adverse effects in aquatic species can occur at 18 mg/l.

No detailed study of 1,1,1-trichloroethane behavior in POTW is available. However, it has been demonstrated that none of the organic priority pollutants of this type can be broken down by biological treatment processes as readily as fatty acids, carbohydrates, or proteins.

Biochemical oxidation of many of the organic priority pollutants has been investigated, at least in laboratory scale studies, at concentrations higher than commonly expected in municipal wastewater. General observations relating molecular structure to ease of degradation have been developed for all of these pollutants. From study of the limited data, it is expected that 1,1,1-trichloroethane will be biochemically oxidized to a lesser extent than domestic sewage by biological treatment in POTW. No evidence is available for drawing conclusions about its possible toxic or inhibitory effect on POTW operation. However, for degradation to occur a fairly constant input of the compound would be necessary.

Its water solubility would allow 1,1,1-trichloroethane, present in the influent and not biodegradable, to pass through a POTW into the effluent. One factor which has received some attention, but no detailed study, is the volatilization of the lower molecular weight organics from POTW. If 1,1,1-trichloroethane is not biodegraded, it will volatilize during aeration processes in the POTW.

2,4,6-Trichlorophenol (21). 2,4,6-Trichlorophenol ($Cl_3C_6H_2OH$, abbreviated here to 2,4,6 TCP) is a colorless crystalline solid at room temperature. It is prepared by the direct chlorination of phenol. 2,4,6-TCP melts at 68°C and is slightly soluble in water (0.8 gm/l at 25°C). This phenol does not produce a color with 4-aminoantipyrene, therefore does not contribute to the nonconventional pollutant parameter "Total Phenols." No data were found on production volumes.

2,4,6-TCP is used as a fungicide, bactericide, glue and wood preservative, and for antimildew treatment. It is also used for the manufacture of 2,3,4,6-tetrachlorophenol and pentachlorophenol.

No data were found on human toxicity effects of 2,4,6-TCP. Reports of studies with laboratory animals indicate that 2,4,6-TCP produced convulsions when injected interperitoneally. Body temperature was also elevated. The compound also produced inhibition of ATP production in isolated rat liver mitochondria, increased mutation rate in one strain of bacteria, and produced a genetic change in rats. No studies on teratogenicity were found.

For the maximum protection of human health from the potential carcinogenic effects of exposure to 2,4,6-trichlorophenol through ingestion of water and contaminated aquatic organisms, the ambient water concentration should be zero. The estimated levels which would result in increased lifetime cancer risks of 10^{-7}, 10^{-6}, and 10^{-5} are 1.18×10^{-5} mg/l, 1.18×10^{-4} mg/l, and 1.18×10^{-3} mg/l, respectively. If contaminated aquatic organisms alone are consumed, excluding the consumption of water, the water concentration should be less than 3.6×10^{-3} mg/l to keep the increased lifetime cancer risk below 10^{-5}. Available data show that adverse effects in aquatic species can occur at 9.7×10^{-4} mg/l.

Although no data were found regarding the behavior of 2,4,6-TCP in POTW, studies of the biochemical oxidation of the compound have been made in a laboratory scale at concentrations higher than those normally expected in municipal wastewaters. Biochemical oxidation of 2,4,6-TCP at 100 mg/l produced 23 percent degradation using a phenol-adapted acclimated seed culture. Based on these results, it is expected that 2,4,6-TCP will be biochemically oxidized to a lesser extent than domestic sewage by biological treatment in POTW. Another study indicates that 2,4,6-TCP may be produced in POTW by chlorination of phenol during normal chlorination treatment.

Para-chloro-meta-cresol (22). Para-chloro-meta-cresol (ClC_7H_6OH) is thought to be 4-chloro-3-methyl-phenol (4-chloro-meta-cresol, or 2 chloro-5-hydroxy-toluene), but is also used by some authorities to refer to 6-chloro-3-methyl-phenol (6-chloro-meta-cresol, or 4-chloro-3-hydroxy-toluene), depending on whether the chlorine is considered to be para to the methyl or to the hydroxy group. It is assumed for the purposes of this document that the subject compound is 2-chloro-5-hydroxy-toluene. This compound is a colorless crystalline solid melting at 66-68°C. It is slightly soluble in water (3.8 gm/l) and soluble in organic solvents. This phenol reacts with 4-aminoantipyrene to give a colored product and therefore contributes to the nonconventional pollutant parameter designated "Total Phenols." No information on manufacturing methods or volumes produced was found.

Para-chloro-meta cresol (abbreviated here as PCMC) is marketed as a microbicide, and was proposed as an antiseptic and disinfectant, more than forty years ago. It is used in glues, gums, paints, inks, textiles, and leather goods. PCMC was found in raw wastewaters from the die casting quench operation from one subcategory of foundry operations.

Although no human toxicity data are available for PCMC, studies on laboratory animals have demonstrated that this compound is toxic when administered subcutaneously and intravenously. Death was preceeded by severe muscle tremors. At high dosages kidney damage occurred. On the other hand, an unspecified isomer of chlorocresol, presumed to be PCMC, is used at a concentration of 0.15 percent to preserve mucous heparin, a natural product administered intervenously as an anticoagulant. The report does not indicate the total amount of PCMC typically received. No information was found regarding possible teratogenicity, or carcinogenicity of PCMC. Based on available organoleptic data, for controlling undesirable taste and odor quality of ambient water, the estimated level is 3 mg/l. Available data show that adverse effects on aquatic life occur at concentrations as low as 0.03 mg/l.

Two reports indicate that PCMC undergoes degradation in biochemical oxidation treatments carried out at concentrations higher than are expected to be encountered in POTW influents. One study showed 59 percent degradation in 3.5 hours when a phenol-adapted acclimated seed culture was used with a solution of 60 mg/l PCMC. The other study showed 100 percent degradation of a 20 mg/l solution of PCMC in two weeks in an aerobic activated sludge test system. No degradation of PCMC occurred under anaerobic conditions. From a review of limited data, it is expected that PCMC will be biochemically oxidized to a lesser extent than domestic sewage by biological treatment in POTWs.

Chloroform(23). Chloroform is a colorless liquid manufactured commercially by chlorination of methane. Careful control of conditions maximizes chloroform production, but other products must be separated. Chloroform boils at 61°C and has a vapor pressure of 200 mm Hg at 25°C. It is slightly soluble in water (8.22 g/l at 20°C) and readily soluble in organic solvents.

Chloroform is used as a solvent and to manufacture refrigerents, pharmaceuticals, plastics, and anesthetics. It is seldom used as an anesthetic.

Toxic effects of chloroform on humans include central nervous system depression, gastrointestinal irritation, liver and kidney damage and possible cardiac sensitization to adrenalin. Carcinogenicity has been demonstrated for chloroform on laboratory animals.

For the maximum protection of human health from the potential carcinogenic effects of exposure to chloroform through ingestion of water and contaminated aquatic organisms, the ambient water concentration is zero. Concentrations of chloroform estimated to result in additional lifetime cancer risks at the levels of 10^{-7}, 10^{-6}, and 10^{-5} were 1.89 x 10^{-5} mg/l, 1.89 x 10^{-4} mg/l, and 1.89 x 10^{-3} mg/l, respectively. If contaminated aquatic organisms alone are consumed, excluding the consumption of water, the water concentration should be less than 0.157 mg/l to keep the increased lifetime cancer risk below 10^{-5}. Available data show that adverse effects on aquatic life occur at concentrations higher than those cited for human health risks.

Few data are available regarding the behavior of chloroform in a POTW. However, the biochemical oxidation of this compound was studied in one laboratory scale study at concentrations higher than those expected to be contained by most municipal wastewaters. After 5, 10, and 20 days no degradation of chloroform was observed. The conclusion reached is that biological treatment produces little or no removal by degradation of chloroform in POTW. An EPA study of the fate of priority pollutants in POTW reveals removal efficiencies of 0 to 80 percent for influent concentrations ranging from 5 to 46 x 10^{-3} mg/l at seven POTW.

The high vapor pressure of chloroform is expected to result in volatilization of the compound from aerobic treatment steps in POTW. Remaining chloroform is expected to pass through into the POTW effluent.

2-Chlorophenol (24). 2-Chlorophenol (ClC_6H_4OH), also called ortho-chlorophenol, is a colorless liquid at room temperature, manufactured by direct chlorination of phenol followed by distillation to separate it from the other principal product, 4-chlorophenol. 2-Chlorophenol solidifies below 7°C and boils at 176°C. It is soluble in water (28.5 gm/l at 20°C) and soluble in several types of organic solvents. This phenol gives a strong color with 4-aninoantipyrene and therefore contributes to the nonconventional pollutant parameter "Total Phenols." Production statistics could not be found. 2-Chlorophenol is used almost exclusively as a chemical intermediate in the production of pesticdes and dyes. Production of some phenolic resins uses 2-chlorophenol.

Very few data are available on which to determine the toxic effects of 2-chlorophenol on humans. The compound is more toxic to laboratory mammals when administered orally than when administered subcataneously or intravenously. This affect is attributed to the fact that the compound is almost completely in the un-ionized state at the low pH of the stomach and hence is more readily absorbed into the body. Initial symptoms are restlessness and increased respiration rate, followed by motor weakness and convulsions induced by noise or touch. Coma follows. Following lethal doses, kidney, liver, and intestinal damage were observed. No studies were found which addressed the teratogenicity or mutagenicity of 2-chlorophenol. Studies of 2-chlorophenol as a promoter of carcinogenic activity of other carcinogens were conducted by dermal application. Results do not bear a determinable relationship to results of oral administration studies.

For controlling undesirable taste and odor quality of ambient water due to the organoleptic properties of 2-chlorophenol in water, the estimated level is 1×10^{-4} mg/l. Available data show that adverse effects on aquatic life occur at concentrations higher than that cited for organaleptic effects.

Data on the behavior of 2-chlorophenol in POTW are not available. However, laboratory scale studies have been conducted at concentrations higher than those expected to be found in municipal wastewaters. At 1 mg/l of 2-chlorophenol, an acclimated culture produced 100 percent degradation by biochemical oxidation after 15 days. Another study showed 45, 70, and 79 percent degradation by biochemical oxidation after 5, 10, and 20 days, respectively. From study of these limited data, and general observations on all organic priority pollutants relating molecular structure to ease of biochemical oxidation, it is expected that 2-chlorophenol will be biochemically oxidized to a lesser extent than domestic sewage by biological treatment in POTW. Undegraded 2-chlorophenol is expected to pass through POTW into the effluent because of the water solubility. Some 2-chlorophenol is also expected to be generated by chlorination treatments of POTW effluents containing phenol.

2,4-Dimethylphenol(34). 2,4-Dimethylphenol (2,4-DMP), also called 2,4-xylenol, is a colorless, crystalline solid at room temperature (25°C), but melts at 27 to 28°C. 2,4-DMP is slightly soluble in water and, as a weak acid, is soluble in alkaline solutions. Its vapor pressure is less than 1 mm Hg at room temperature.

2,4-DMP is a natural product, occurring in coal and petroleum sources. It is used commercially as a intermediate for manufacture of pesticides, dystuffs, plastics and resins, and surfactants. It is found in the water runoff from asphalt surfaces. It can find its way into the wastewater of a manufacfuring plant from any of several adventitious sources.

Analytical procedures specific to this compound are used for its identification and quantification in wastewaters. This compound does not contribute to "Total Phenol" determined by the 4-aminoantipyrene method.

Three methylphenol isomers (cresols) and six dimethylphenol isomers (xylenols) generally occur together in natural products, industrial processes, commercial products, and phenolic wastes. Therefore, data are not available for human exposure to 2,4-DMP alone. In addition to this, most mammalian tests for toxicity of individual dimethylphenol isomers have been conducted with isomers other than 2,4-DMP.

In general, the mixtures of phenol, methylphenols, and dimethylphenols contain compounds which produced acute poisoning in laboratory animals. Symptoms were difficult breathing, rapid muscular spasms, disturbance of motor coordination, and assymetrical body position. In a 1977 National Academy of Science publication the conclusion was reached that, "In view of the relative paucity of data on the mutagenicity, carcinogenicity, teratogenicity, and long term oral toxicity of 2,4 dimethylphenol, estimates of the effects of chronic oral exposure at low levels cannot be made with any confidence." No ambient water quality criterion can be set at this time. In order to protect public health, exposure to this compound should be minimized as soon as possible.

Toxicity data for fish and freshwater aquatic life are limited. Acute toxicity to freshwater aquatic life occurs at 2,4-dimethylphenol concentrations of 2.12 mg/l. For controlling undesirable taste and odor quality of ambient water due to the organoleptic effects of 2,4-dimethylphenol in water the estimated level is 0.4 mg/l.

The behavior of 2,4-DMP in POTW has not been studied. As a weak acid its behavior may be somewhat dependent on the pH of the influent to the POTW. However, over the normal limited range of POTW pH, little effect of pH would be expected.

Biological degradability of 2,4-DMP as determined in one study, showed 94.5 percent biochemical oxidation after 110 hours using an adapted culture. Thus, it is expected that 2,4-DMP will be biochemically oxidized to about the same extent as domestic sewage by biological treatment in POTW. Another study determined that persistance of 2,4-DMP in the environment is low, thus any of the compound which remained in the sludge or passed through the POTW into the effluent would be degraded within moderate length of time (estimated as 2 months in the report).

2,4-Dinitrotoluene (35). 2,4-Dinitrotoluene $[(NO_2)_2C_6H_3CH_3]$, a yellow crystalline compound, is manufactured as a coproduct with the 2,6 isomer by nitration of nitrotoluene. It melts at 71°C. 2,4-Dinitrotoluene is insoluble in water (0.27 g/l at 22°C) and soluble in a number of organic solvents. Production data for the 2,4-isomer alone are not available. The 2,4-and 2,6-isomers are manufactured in an 80:20 or 65:35 ratio, depending on the process used. Annual U.S. commercial production is about 150 thousand tons of the two isomers. Unspecified amounts are produced by the U.S. government and further nitrated to trinitrotoluene (TNT) for military use.

The major use of the dinitrotoluene mixture is for production of toluene diisocyanate used to make polyurethanes. Another use is in production of dyestuffs.

The toxic effect of 2,4-dinitrotoluene in humans is primarily methemoglobinemia (a blood condition hindering oxygen transport by the blood). Symptoms depend on severity of the disease, but include cyanosis, dizziness, pain in joints, headache, and loss of appetite in workers inhaling the compound. Laboratory animals fed oral doses of 2,4-dinitrotoluene exhibited many of the same symptoms. Aside from the effects in red blood cells, effects are observed in the nervous system and testes.

Chronic exposure to 2,4-dinitrotoluene may produce liver damage and reversible anemia. No data were found on teratogenicity of this compound. Mutagenic data are limited and are regarded as confusing. Data resulting from studies of carcinogenicity of 2,4-dinitrotoluene point to a need for further testing for this property.

For the maximum protection of human health from the potential carcinogenic effects of exposure to 2,4-dinitrotoluene through ingestion of water and contaminated aquatic organisms, the ambient water concentration is zero. Concentrations of 2,4-dinitrotoluene estimated to result in additional lifetime cancer risk at risk levels of 10^{-7}, 10^{-6}, and 10^{-5} are 1.11×10^{-5} mg/l, 1.11×10^{-4} mg/l, and 1.11×10^{-3} mg/l, respectively. If aquatic organisms alone are consumed, the water concentration should be less than 0.091 mg/l to keep the increased lifetime cancer risk below 10^{-5}. Available data show that adverse effects in aquatic life occur at concentrations higher than those cited for human health risks.

Data on the behavior of 2,4-dinitrotoluene in POTW are not available. However, biochemical oxidation of 2,4-dinitrotoluene was investigated on a laboratory scale. At 100 mg/l of 2,4-dinitrotoluene, a concentration considerably higher than that expected in municipal wastewaters, biochemical oxidation by an acclimated, phenol-adapted seed culture produced 52 percent degradation in three hours. Based on this limited information and general observations relating molecular structure to ease of degradation for all the organic priority pollutants, it is expected that 2,4-dinitrotoluene will be biochemically oxidized to about the same extent as domestic sewage by biological treatment in POTW. No information is available regarding possible interference by 2,4-dinitrotoluene in POTW treatment processes, or on the possible detrimental effect on sludge used to amend soils in which food crops are grown.

2,6-Dinitrotoluene (36). 2,6-Dinitrotoluene $[(NO_2)_2C_6H_3CH_3]$ is a crystalline solid produced as a coproduct with 2,4-dinitrotoluene by nitration of nitrotoluene. It melts at 66C. No solubility or vapor pressure data are given in the literature, but this compound is expected to be insoluble just as the 2,4-dinitrotoluene isomer is (0.27 g/l at 22C). Production data for the 2,6-isomer are not available. The 2,4- and 2,6- isomers are manufactured in an 80:20 or 65:35 ratio depending on the process used. Annual U.S. commercial production is about 150 thousand tons of the two isomers. Unspecified amounts are produced by the U.S. government and further nitrated to trinitrotoluene (TNT) for military use.

The major use of the dinitrotoluene mixture is for production of toluene diisocyanate used to make polyurethanes. Another use is in production of dyestuffs.

No toxicity data are available in the literature for 2,6-dinitrotoluene. The 2,4-isomer is toxic and is classed as a potential carcinogen on the basis of tumerogenic effects and other considerations. No ambient water criterion has been established for 2,6-dinitrotoluene.

Data on the behavior of 2,6-dinitrotoluene in POTW are not available. Biochemical oxidation of many of the organic priority pollutants have been investigated, at least in laboratory scale studies, at concentrations higher than those expected to be contained by most municipal wastewaters. General observations have been developed relating molecular structure to ease of degradation for all the organic priority pollutants. Based on study of the limited data, it is expected that 2,6-dinitrotoluene will be biochemically oxidized to a lesser extent than domestic sewage by biological treatment in POTW. No information is available regarding possible interferance by 2,6-dinitrotoluene in POTW processes, or the possible detrimental effect on sludge used to amend soils in which crops are grown.

Ethylbenzene(38). Ethylbenzene is a colorless, flammable liquid manufactured commercially from benzene and ethylene. Approximately half of the benzene used in the U.S. goes into the manufacture of more than three million tons of ethylbenzene annually. Ethylbenzene boils at 136°C and has a vapor pressure of 7 mm Hg at 20°C. It is slightly soluble in water (0.14 g/l at 15°C) and is very soluble in organic solvents.

About 98 percent of the ethylbenzene produced in the U.S. goes into the production of styrene, much of which is used in the plastics and synthetic rubber industries. Ethylbenzene is a constituent of xylene mixtures used as diluents in the paint industry, agricultural insecticide sprays, and gasoline blends.

Although humans are exposed to ethylbenzene from a variety of sources in the environment, little information on effects of ethylbenzene in man or animals is available. Inhalation can irritate eyes, affect the respiratory tract, or cause vertigo. In laboratory animals ethylbenzene exhibited low toxicity. There are no data available on teratogenicity, mutagenicity, or carcinogenicity of ethylbenzene.

Criteria are based on data derived from inhalation exposure limits. For the protection of human health from the toxic properties of ethylbenzene ingested through water and contaminated aquatic organisms, the ambient water criterion is 1.4 mg/l. If contaminated aquatic organisms alone are consumed, excluding the consumption of water, the ambient water criterion is 3.28 mg/l. Available data show that at concentrations of 0.43 mg/l, adverse effects on aquatic life occur.

The behavior of ethylbenzene in POTW has not been studied in detail. Laboratory scale studies of the biochemical oxidation of ethylbenzene at concentrations greater than would normally be found in municipal wastewaters have demonstrated varying degrees of degradation. In one study with phenol-acclimated seed cultures 27 percent degradation was observed in a half day at 250 mg/l ethyl- bezene. Another study at unspecified conditions showed 32, 38, and 45 percent degradation after 5, 10, and 20 days, respectively. Based on these results and general observations relating molecular structure to ease of degradation, it is expected that ethylbenzene will be biochemically oxidized to a lesser extent than domestic sewage by biological treatment in POTW.

An EPA study of seven POTW showed removals of 77 to 100 percent in five POTW having influent ethylbenzene concentrations of 10 to 44 x 10^{-3} mg/l. The other two POTW had influent concentrations of 2 x 10^{-3} mg/l or less. Other studies suggest that most of the ethylbenzene entering a POTW is removed from the aqueous stream to the sludge. The ethylbenzene contained in the sludge removed from the POTW may volatilize.

Fluoranthene(39). Fluoranthene (1,2-benzacenaphthene) is one of the compcunds called polynuclear aromatic hydrocarbons (PAH). A pale yellow solid at room temperature, it melts at 111°C and has a negligible vapor pressure at 25°C. Water solubility is low (0.2 mg/l). Its molecular formula is $C_{16}H_{10}$.

Fluoranthene, along with many other PAH's, is found throughout the environment. It is produced by pyrolytic processing of organic raw materials, such as coal and petroleum, at high temperature (coking processes). It occurs naturally as a product of plant biosyntheses. Cigarette smoke contains fluoranthene. Although it is not used as the pure compound in industry, it has been found at relatively higher concentrations (0.002 mg/l) than most other PAH's in at least one industrial effluent. Furthermore, in a 1977 EPA survey to determine levels of PAH in U.S. drinking water supplies, none of the 110 samples analyzed showed any PAH other than fluoranthene.

Experiments with laboratory animals indicate that fluoranthene presents a relatively low degree of toxic potential from acute exposure, including oral administration. Where death occured, no information was reported concerning target organs or specific cause of death.

There is no epidemiological evidence to prove that PAH in general, and fluoranthene, in particular, present in drinking water are related to the development of cancer. The only studies directed toward determining carcinogenicity of fluoranthene have been skin tests on laboratory animals. Results of these tests show that fluoranthene has no activity as a complete carcinogen (i.e., an agent which produces cancer when applied by itself, but exhibits significant cocarcinogenicity (i.e., in combination with a carcinogen, it increases the carcinogenic activity).

Based on the limited animal study data, and following an establishing procedure, the ambient water criterion for fluoranthene through water and contaminated aquatic organisms is determined to be 0.042 mg/l for the protection of human health from its toxic properties. If contaminated aquatic organisms alone are consumed, excluding the consumption of water, the ambient water criterion is 0.054 mg/l. Available data show that adverse effects on aquatic life occur at concentrations of 0.016 mg/l.

Results of studies of the behavior of fluoranthene in conventional sewage treatment processes found in POTW have been published. Removal of fluoranthene during primary sedimentation was found to be 62 to 66 percent (from an initial value of 0.00323 to 0.0435 mg/l to a final value of 0.00122 to 0.0146 mg/l), and the removal was 91 to 99 percent (final values of 0.00028 to 0.00026 mg/l) after biological purification with activated sludge processes.

A review was made of data on biochemical oxidation of many of the organic priority pollutants investigated in laboratory scale studies at concentrations higher than would normally be expected in municipal wastewater. General observations relating molecular structure to ease of degradation have been developed for all of these pollutants. The conclusion reached by study of the limited data is that biological treatment produces little or no degradation of fluoranthene. The same study however concludes that fluoranthene would be readily removed by filtration and oil water separation and other methods which rely on water insolubility, or adsorption on other particulate surfaces. This latter conclusion is supported by the previously cited study showing significant removal by primary sedimentation.

No studies were found to give data on either the possible interference of fluoranthene with POTW operation, or the persistance of fluoranthene in sludges on POTW effluent waters. Several studies have documented the ubiquity of fluoranthene in the environment and it cannot be readily determined if this results from persistance of anthropogenic fluoranthene or the replacement of degraded fluoranthene by natural processes such as biosynthesis in plants.

Isophorone(54). Isophorone is an industrial chemical produced at a level of tens of millions of pounds annually in the U.S. The chemical name for isophorone is 3,5,5-trimethyl-2-cyclohexen-1-one and it is also known as trimethyl cyclohexanone and isoacetophorone. The formula is $C_6H_5(CH_3)_3O$. Normally, it is produced as the gamma isomer; technical grades contain about 3 percent of the beta isomer (3,5-5-trimethyl-3-cyclohexen-1-one). The pure gamma isomer is a water-white liquid, with vapor pressure less than 1 mm Hg at room temperature, and a boiling point of 215.2°C. It has a camphor- or peppermint-like odor and yellows upon standing. It is slightly soluble (12 mg/l) in water and dissolves in fats and oils.

Isophorone is synthesized from acetone and is used commercially as a solvent or cosolvent for finishes, lacquers, polyvinyl and nitrocellulose resins, pesticides, herbicides, fats, oils, and gums. It is also used as a chemical feedstock.

Because isophorone is an industrially used solvent, most toxicity data are for inhalation exposure. Oral administration to laboratory animals in two different studies revealed no acute or chronic effects during 90 days, and no hematological or pathological abnormalities were reported. Apparently, no studies have been completed on the carcinogenicity of isophorone.

Isophorone does undergo bioconcentration in the lipids of aquatic organisms and fish.

The ambient water criterion for isophorone ingested through consumption of water and fish is determined to be 5.2 mg/l for the protection of human health from its toxic properties. If contaminated aquatic organisms alone are consumed, excluding the consumption of water, the ambient water criteria is 520 mg/l. Available data show that adverse effects in aquatic life occur at concentrations as low as 12.9 mg/l.

The behavior of isophorone in POTW has not been studied. However, the biochemical oxidation of many of the organic priority pollutants has been investigated in laboratory-scale studies at concentrations higher than would normally be expected in municipal wastewater. General observations relating molecular structure to ease of degradation have been developed for all of these pollutants. Based on the study of the limited data, it is expected that isophorone will be biochemically oxidized to a lesser extent than domestic sewage by biological treatment in POTW. This conclusion is consistant with the findings of an experimental study of microbiological degradation of isophorone which showed about 45 percent biooxidation in 15 to 20 days in domestic wastewater, but only 9 percent in salt water. No data were found on the persistance of isophorone in sewage sludge.

Naphthalene(55). Naphthalene is an aromatic hydrocarbon with two orthocondensed benzene rings and a molecular formula of $C_{10}H_8$. As such it is properly classed as a polynuclear aromatic hydrocarbon (PAH). Pure naphthalene is a white crystalline solid melting at 80°C. For a solid, it has a relatively high vapor pressure (0.05 mm Hg at 20°C), and moderate water solubility (19 mg/l at 20°C). Naphthalene is the most abundant single component of coal tar. Production is more than a third of a million tons annually in the U.S. About three fourths of the production is used as feedstock for phthalic anhydride manufacture. Most of the remaining production goes into manufacture of insecticide, dystuffs, pigments, and pharmaceuticals. Chlorinated and partially hydrogenated naphthalenes are used in some solvent mixtures. Naphthalene is also used as a moth repellent.

Napthalene, ingested by humans, has reportedly caused vision loss (cataracts), hemolytic anemia, and occasionally, renal disease. These effects of naphthalene ingestion are confirmed by studies on laboratory animals. No carcinogenicity studies are available which can be used to demonstrate carcinogenic activity for naphthalene. Naphthalene does bioconcentrate in aquatic organisms.

The available data base is insufficient to establish an ambient water criterion for the protection of human health from the toxic properties of naphthalene. Available data show that adverse effects on aquatic life occur at concentrations as low as 0.62 mg/l.

Only a limited number of studies have been conducted to determine the effects of naphthalene on aquatic organisms. The data from those studies show only moderate toxicity.

Naphthalene has been detected in sewage plant effluents at concentrations up to 22 µg/l in studies carried out by the U.S. EPA. Influent levels were not reported. The behavior of naphthalene in

POTW has not been studied. However, recent studies have determined that naphthalene will accumulate in sediments at 100 times the concentration in overlying water. These results suggest that naphthalene will be readily removed by primary and secondary settling in POTW, if it is not biologically degraded.

Biochemical oxidation of many of the organic priority pollutants has been investigated in laboratory-scale studies at concentrations higher than would normally be expected in municipal wastewater. General observations relating molecular structure to ease of degradation have been developed for all of these pollutants. Based on the study of the limited data, it is expected that naphthalene will be biochemically oxidized to about the same extent as domestic sewage by biological treatment in POTW. One recent study has shown that microorganisms can degrade naphthalene, first to a dihydro compound, and ultimately to carbon dioxide and water.

2-Nitrophenol (57). 2-Nitrophenol ($NO_2C_6H_4OH$), also called ortho-nitrophenol, is a light yellow crystalline solid, manufactured commercially by hydrolysis of 2-chloro-nitrobenzene with aqueous sodium hydroxide. 2-Nitrophenol melts at 45°C and has a vapor pressure of 1 mm Hg at 49°C. 2-Nitrophenol is slightly soluble in water (2.1 g/l at 20°C) and soluble in organic solvents. This phenol does not react to give a color with 4-aminoantipyrene, and therefore does not contribute to the nonconventional pollutant parameter "Total Phenols. U.S. annual production is five thousand to eight thousand tons.

The principle use of ortho-nitrophenol is to synthesize ortho-aminophenol, ortho-nitroanisole, and other dyestuff intermediates.

The toxic effects of 2-nitrophenol on humans have not been extensively studied. Data from experiments with laboratory animals indicate that exposure to this compound causes kidney and liver damage. Other studies indicate that the compound acts directly on cell membranes, and inhibits certain enzyme systems *in vitro*. No information regarding potential teratogencity was found. Available data indicate that this compound does not pose a mutagenic hazard to humans. Very limited data for 2-nitrophenol do not reveal potential carcinogenic effects.

The available data base is insufficient to establish an ambient water criterion for protection of human health from exposure to 2-nitrophenol. No data are available on which to evaluate the adverse effects of 2-nitrophenol on aquatic life.

Data on the behavior of 2-nitrophenol in POTW were not available. However, laboratory-scale studies have been conducted at concentrations higher than those expected to be found in municipal wastewater. Biochemical oxidation using adapted cultures from various sources produced 95 percent degradation in three to six days in one study. Similar results were reported for other studies. Based on these data, and general observations relating molecular structure to ease of biological oxidation, it is expected that 2-nitrophenol will be biochemically oxidized to a lesser extent than domestic sewage by biological treatment in POTWs.

4,6-dinitro-o-cresol (60). 4,6-dinitro-o-cresol (DNOC) is a yellow crystalline solid derived from o-cresol. DNOC melts at 85.8°C and has a vapor pressure of 0.000052 mm Hg at 20°C. DNOC is sparingly soluble in water (100 mg/l at 20°C), while it is readily soluble in alkaline aqueous solutions, ether, acetone, and alcohol. DNOC is produced by sulfonation of o-cresol followed by treatment with nitric acid.

DNOC is used primarily as a blossom thinning agent on fruit trees and as a fungicide, insecticide and miticide on fruit trees during the dormant season. It is highly toxic to plants in the growing stage. DNOC is not manufactured in the U.S. as an agricultural chemical. Imports of DNOC have been decreasing recently with only 30,000 lbs being imported in 1976.

While DNOC is highly toxic to plants, it is also very toxic to humans and is considered to be one of the more dangerous agricultural pesticides. The available literature concerning humans indicates that DNOC may be absorbed in acutely toxic amounts through the respiratory and gastrointestinal tracts and through the skin, and that it accumulates in the blood. Symptoms of poisoning inlude profuse sweating, thirst, loss of weight, headache, malaise, and yellow staining to the skn, hair, sclera, and conjunctiva.

There is no evidence to suggest that DNOC is teratogenic, mutagenic, or carcinogenic. The effects of DNOC in the human due to chronic exposure are basically the same as those effects resulting from acute exposure. Although DNOC is considered a cumulative poison in humans, cataract formation is the only chronic effect noted in any human or experimental animal study. It is believed that DNOC accumulates in the human body and that toxic symptoms may develop when blood levels exceed 20 mg/kg.

For the protection of human health from the toxic properties of dinitro-o-cresol ingested through water and contaminanted aquatic organisms, the ambient water criterion is determined to be 0.0134 mg/l. If contaminated aquatic organisms alone are consumed, excluding the consumption of water, the ambient water criterion is determined to be 0.765 mg/l. No data are available on which to evaluate the adverse effects of 4,6-dinitro-o-cresol on aquatic life.

Some studies have been reported regarding the behavior of DNOC in POTW. Biochemical oxidation of DNOC under laboratory conditions at a concentration of 100 mg/l produced 22 percent degradation in 3.5 hours, using acclimated phenol adapted seed cultures. In addition, the nitro group in the number 4 (para) position seems to impart a destabilizing effect on the molecule. Based on these data and general conclusions relating molecular structure to biochemical oxidation, it is expected that 4,6-dinitro-o-cresol will be biochemically oxidized to a lesser extent than domestic sewage by biological treatment in POTW.

Pentachlorophenol(64). Pentachlorophenol (C_6Cl_5OH) is a white crystalline solid produced commercially by chlorination of phenol or polychlorophenols. U.S. annual production is in excess of 20,000 tons. Pentachlorophenol melts at 190°C and is slightly soluble in water (14 mg/l). Pentachlorophenol is not detected by the 4-amino antipyrene method.

Pentachlorophenol is a bactericide and fungacide and is used for preservation of wood and wood products. It is competative with creosote in that application. It is also used as a preservative in glues, starches, and photographic papers. It is an effective algicide and herbicide.

Although data are available on the human toxicity effects of pentachlorophenol, interpretation of data is frequently uncertain. Occupational exposure observations must be examined carefully because exposure to pentachlorophenol is frequently accompained by exposure to other wood preservatives. Additionally, experimental results and occupational exposure observations must be examined carefully to make sure that observed effects are produced by the pentachlorophenol itself and not by the by-products which usually contaminate pentachlorophenol.

Acute and chronic toxic effects of pentachlorophenol in humans are similar; muscle weakness, headache, loss of appetite, abdominal pain, weight loss, and irritation of skin, eyes, and respiratory tract. Available literature indicates that pentachlorophenol does not accumulate in body tissues to any significant extent. Studies on laboratory animals of distribution of the compound in body tissues showed the highest levels of pentachlorophenol in liver, kidney, and intestine, while the lowest levels were in brain, fat, muscle, and bone.

Toxic effects of pentachlorophenol in aquatic organisms are much greater at pH of 6 where this weak acid is predominantly in the undissociated form than at pH of 9 where the ionic form predominates. Similar results were observed in mammals where oral lethal doses of pentachlorophenol were lower when the compound was administered in hydrocarbon solvents (un-ionized form) than when it was administered as the sodium salt (ionized form) in water.

There appear to be no significant teratogenic, mutagenic, or carcinogenic effects of pentachlorophenol.

For the protection of human health from the toxic properties of pentachlorophenol ingested through water and through contaminated aquatic organisms, the ambient water quality criterion is determined to be 1.01 mg/l. If contaminated aquatic organisms alone are consumed, excluding the consumption of water, the ambient water criterion is determined to be 29.4 mg/l. Available data show that adverse effects on aquatic life occur at concentration as low as 0.0032 mg/l.

Only limited data are available for reaching conclusions about the behavior of pentachlorophenol in POTW. Pentachlorophenol has been found in the influent to POTW. In a study of one POTW the mean removal was 59 percent over a 7 day period. Trickling filters removed 44 percent of the influent pentachlorophenol suggesting that biological degradation occurs. The same report compared removal of pentachlorophenol of the same plant and two additional POTW on a later date and obtained values of 4.4, 19.5 and 28.6 percent removal, the last value being for the plant which was 59 percent removal in the original study. Influent concentrations of pentachloropehnol ranged from 0.0014 to 0.0046 mg/l. Other studies, including the general review of data relating molecular structure to biological oxidation, indicate that pentachlorophenol is not biochemically oxidized by biological treatment processes in POTW. Anaerobic digestion processes are inhibited by 0.4 mg/l pentachlorophenol.

The low water solubility and low volatility of pentachloro- phenol lead to the expectation that most of the compound will remain in the sludge in a POTW. The effect on plants grown on land treated with sludge containing pentachlorophenol is unpredicatable. Laboratory studies show that this compound affects crop germination at 5.4 mg/l. However, photodecomposition of pentachlorophenol occurs in sunlight. The effects of the various breakdown products which may remain in the soil was not found in the literature.

Phenol(65). Phenol, also called hydroxybenzene and carbolic acid, is a clear, colorless, hygroscopic, deliquescent, crystalline solid at room temperature. Its melting point is 43°C and its vapor pressure at room temperature is 0.35 mm Hg. It is very soluble in water (67 gm/l at 16°C) and can be dissolved in benzene, oils, and petroleum solids. Its formula is C_6H_5OH.

Although a small percent of the annual production of phenol is derived from coal tar as a naturally occuring product, most of the phenol is synthesized. Two of the methods are fusion of benzene sulfonate with sodium hydroxide, and oxidation of cumene followed by clevage with a catalyst. Annual production in the U.S. is in excess of one million tons. Phenol is generated during distillation of wood and the microbiological decomposition of organic matter in the mammalian intestinal tract.

Phenol is used as a disinfectant, in the manufacture of resins, dyestuffs, and pharmaceuticals, and in the photo processing industry. Phenol was detected on only one day in one coil coating raw waste stream out of 14 days of sampling and analysis at 11 coil coating plants. In this discussion, phenol is the specific compound which is separated by methylene chloride extraction of an acidified sample and identified and quantified by GC/MS. Phenol also contributes to the "Total Phenols", discussed elsewhere which are determined by the 4-AAP colorimetric method.

Phenol exhibits acute and sub-acute toxicity in humans and laboratory animals. Acute oral doses of phenol in humans cause sudden collapse and un- consciousness by its action on the central nervous system. Death occurs by respiratory arrest. Sub-acute oral doses in mammals are rapidly absorbed then quickly distributed to various organs, then cleared from the body by urinary excretion and metabolism. Long term exposure by drinking phenol contaminated water has resulted in statistically significant increase in reported cases of diarrhea, mouth sores, and burning of the mouth. In laboratory animals long term oral administration at low levels produced slight liver and kidney damage. No reports were found regarding carcinogenicity of phenol administered orally - all carcinogenicity studies were skin tests.

For the protection of human health from phenol ingested through water and through contaminated aquatic organisms the ambient water criterion is determined to be 3.5 mg/l. If contaminated aquatic organisms alone are consumed, excluding the consumption of water, the ambient water criterion is 769 mg/l. Available data show that adverse effects in aquatic life occur at concentrations as low as 2.56 mg/l.

Data have been developed on the behavior of phenol in POTW. Phenol is biodegradable by biota present in POTW. The ability of a POTW to treat phenol-bearing influents depends upon acclimation of the biota and the constancy of the phenol concentration. It appears that an induction period is required to build up the population of organisms which can degrade phenol. Too large a concentration will result in upset or pass through in the POTW, but the specific level causing upset depends on the immediate past history of phenol concentrations in the influent. Phenol levels as high as 200 mg/l have been treated with 95 percent removal in POTW, but more or less continuous presence of phenol is necessary to maintain the population of microorganisms that degrade phenol. An EPA study of seven POTWs revealed that only three POTW showed a decrease in phenol concentration between influent (14, 1, and 1×10^{-3} mg/l) and effluent (1×10^{-3} mg/l, and 0, respectively).

Phenol which is not degraded is expected to pass through the POTW because of its very high water solubility. However, in POTW where chlorination is practiced for disinfection of the POTW effluent, chlorination of phenol may occur. The products of that reaction may be priority pollutants.

The EPA has developed data on influent and effluent concentrations of total phenols in a study of 103 POTW. However, the analytical procedure was the 4-AAP method mentioned earlier and not the GC/MS method specifically for phenol. Discussion of the study, which of course includes phenol, is presented under the pollutant heading "Total Phenols."

Phthalate Esters (66-71). Phthalic acid, or 1,2-benzenedicarboxylic acid, is one of three isomeric benzenedicarboxylic acids produced by the chemical industry. The other two isomeric forms are called isophthalic and terephathalic acids. The formula for all three acids is $C_6H_4(COOH)_2$. Some esters of phthalic acid are designated as priority pollutants. They will be discussed as a group here, and specific properties of individual phthalate esters will be discussed afterwards.

Phthalic acid esters are manufactured in the U.S. at an annual rate in excess of 1 billion pounds. They are used as plasticizers - primarily in the production of polyvinyl chloride (PVC) resins. The most widely statistically significant increase in reported cases of diarrhea, mouth sores, and burning of the mouth. In laboratory animals long term oral administration at low levels produced slight liver and kidney damage. No reports were found regarding carcinogenicity of phenol administered orally - all carcinogenicity studies were skin tests.

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Phthalic acid esters are manufactured in the U.S. at an annual rate in excess of 1 billion pounds. They are used as plasticizers - primarily in the production of polyvinyl chloride (PVC) resins. The most widely used phthalate plasticizer is bis (2-ethylhexyl) phthalate (66) which accounts for nearly one third of the phthalate esters produced. This particular ester is commonly referred to as dioctyl phthalate (DOP) and should not be confused with one of the less used esters, di-n-octyl phthalate (69), which is also used as a plastcizer. In addition to these two isomeric dioctyl phthalates, four other esters, also used primarily as plasticizers, are designated as priority pollutants. They are: butyl benzyl phthalate (67), di-n-butyl phthalate (68), diethyl phthalate (70), and dimethyl phthalate (71).

Industrially, phthalate esters are prepared from phthalic anhydride and the specific alcohol to form the ester. Some evidence is available suggesting that phthalic acid esters also may be synthesized by certain plant and animal tissues. The extent to which this occurs in nature is not known.

Phthalate esters used as plasticizers can be present in concentrations up to 60 percent of the total weight of the PVC plastic. The plasticizer is not linked by primary chemical bonds to the PVC resin. Rather, it is locked into the structure of intermeshing polymer molecules and held by van der Waals forces. The result is that the plasticizer is easily extracted. Plasticizers are responsible for the odor associated with new plastic toys or flexible sheet that has been contained in a sealed package.

Although the phthalate esters are not soluble or are only very slightly soluble in water, they do migrate into aqueous solutions placed in contact with the plastic. Thus industrial facilities with tank linings, wire and cable coverings, tubing, and sheet flooring of PVC are expected to discharge some phthalate esters in their raw waste. In addition to their use as plasticizers, phthalate esters are used in lubricating oils and pesticide carriers. These also can contribute to industrial discharge of phthalate esters.

From the accumulated data on acute toxicity in animals, phthalate esters may be considered as having a rather low order of toxicity. Human toxicity data are limited. It is thought that the toxic effects of the esters is most likely due to one of the metabolic products, in particular the monoester. Oral acute toxicity in animals is greater for the lower molecular weight esters than for the higher molecular weight esters.

Orally administered phthalate esters generally produced enlarging of liver and kidney, and atrophy of testes in laboratory animals. Specific esters produced enlargement of heart and brain, spleenitis, and degeneration of central nervous system tissue.

Subacute doses administered orally to laboratory animals produced some decrease in growth and degeneration of the testes. Chronic studies in animals showed similar effects to those found in acute and subacute studies, but to a much lower degree. The same organs were enlarged, but pathological changes were not usually detected.

A recent study of several phthalic esters produced suggestive but not conclusive evidence that dimethyl and diethyl phthalates have a cancer liability. Only four of the six priority pollutant esters were included in the study. Phthalate esters do biconcentrate in fish. The factors, weighted for relative consumption of various aquatic and marine food groups, are used to calculate ambient water quality criteria for four phthalate esters. The values are included in the discussion of the specific esters.

Studies of toxicity of phthalate esters in freshwater and salt water organisms are scarce. Available data show that adverse effects on aquatic life occur at phthalate ester concentrations as low as 0.003 mg/l.

The behavior of phthalate esters in POTW has not been studied. However, the biochemical oxidation of many of the organic priority pollutants has been investigated in laboratory-scale studies at concentrations higher than would normally be expected in municipal wastewater. Three of the phthalate esters were studied. Bis(2-ethylhexyl) phthalate was found to be degraded slightly or not at all and its removal by biological treatment in a POTW is expected to be slight or zero. Di-n-butyl phthalate and diethyl phthalate were degraded to a moderate degree and it is expected that they will be biochemically oxidized to a lesser extent than domestic sewage by biological treatment in POTW. Based on these data and other observations relating molecular structure to ease of biochemical degradation of other organic pollutants, it is expected that butyl benzyl phthalate and dimethyl phthalate will be biochemically oxidized to a lesser extent than domestic sewage by biological treatment in POTW. On the same basis, it is expected that di-n-octyl phthalate will not be biochemically oxidized to a significant extent by biological treatment in POTW. An EPA study of seven POTW revealed that for all but di-n-octyl phthalate, which was not studied, removals ranged from 62 to 87 percent.

No information was found on possible interference with POTW operation or the possible effects on sludge by the phthalate esters. The water insoluble phthalate esters - butylbenzyl and di-n-octyl phthalate - would tend to remain in sludge, whereas the other four priority pollutant phthalate esters with water solubilities ranging from 50 mg/l to 4.5 mg/l would probably pass through into the POTW effluent.

Bis (2-ethylhexyl) phthalate(66). In addition to the general remarks and discussion on phthalate esters, specific information on bis(2-ethylhexyl) phthalate is provided. Little information is available about the physical properties of bis(2-ethylhexyl) phthalate. It is a liquid boiling at 387°C at 5mm Hg and is insoluble in water. Its formula is $C_6H_4(COOC_8H_{17})_2$. This priority pollutant constitutes about one third of the phthalate ester production in the U.S. It is commonly referred to as dioctyl phthalate, or DOP, in the plastics industry where it is the most extensively used compound for the plasticization of polyvinyl chloride (PVC). Bis(2-ethylhexyl) phthalate has been approved by the FDA for use in plastics in contact with food. Therefore, it may be found in wastewaters coming in contact with discarded plastic food wrappers as well as the PVC films and shapes normally found in industrial plants. This priority pollutant is also a commonly used organic diffusion pump oil where its low vapor pressure is an advantage.

For the protection of human health from the toxic properties of bis(2-ethylhexyl) phthalate ingested through water and through contaminated aquatic organisms, the ambient water criterion is determined to be 15 mg/l. If contaminated aquatic organisms alone are consumed, excluding the consumption of water, the ambient water criteria is determined to be 50 mg/l.

Although the behavior of bis(2-ethylhexyl) phthalate in POTW has not been studied, biochemical oxidation of this priority pollutant has been studied on a laboratory scale at concentrations higher than would normally be expected in municipal wastewater. In fresh water with a nonacclimated seed culture no biochemical oxidation was observed after 5, 10, and 20 days. However, with an acclimated seed culture, biological oxidation occurred to the extents of 13, 0, 6, and 23 of theoretical after 5, 10, 15 and 20 days, respectively. Bis(2-ethylhexyl) phthalate concentrations were 3 to 10 mg/l. Little or no removal of bis(2-ethylhexyl) phthalate by biological treatment in POTW is expected.

Butyl benzyl phthalate(67). In addition to the general remarks and discussion on phthalate esters, specific information on butyl benzyl phthalate is provided. No information was found on the physical properties of this compound.

Butyl benzyl phthalate is used as a plasticizer for PVC. Two special applications differentiate it from other phthalate esters. It is approved by the U.S. FDA for food contact in wrappers and containers; and it is the industry standard for plasticization of vinyl flooring because it provides stain resistance.

No ambient water criterion is proposed for butyl benzyl phthalate.

Butyl benzyl phthalate removal in POTWs is discussed in the general discussion of phthalate esters.

Di-n-butyl phthalate (68). In addition to the general remarks and discussion on phthalate esters, specific information on di-n-butyl phthalate (DBP) is provided. DBP is a colorless, oily liquid, boiling at 340°C. Its water solubility at room temperature is reported to be 0.4 g/l and 4.5g/l in two different chemistry handbooks. The formula for DBP, $C_6H_4(COOC_4H_9)_2$ is the same as for its isomer, di-isobutyl phthalate. DCP production is one to two percent of total U.S. phthalate ester production.

Dibutyl phthalate is used to a limited extent as a plasticizer for polyvinylchloride (PVC). It is not approved for contact with food. It is used in liquid lipsticks and as a diluent for polysulfide dental impression materials. DBP is used as a plasticizer for nitrocellulose in making gun powder, and as a fuel in solid propellants for rockets. Further uses are insecticides, safety glass manufacture, textile lubricating agents, printing inks, adhesives, paper coatings and resin solvents.

For protection of human health from the toxic properties of dibutyl phthalate ingested through water and through contaminated aquatic organisms, the ambient water criterion is determined to be 34 mg/l. If contaminated aquatic organisms alone are consumed, excluding the consumption of water, the ambient water criterion is 154 mg/l.

Although the behavior of di-n-butyl phthalate in POTW has not been studied, biochemical oxidation of this priority pollutant has been studied on a laboratory scale at concentrations higher than would normally be expected in municipal wastewater. Biochemical oxidation of 35, 43, and 45 percent of theoretical oxidation were obtained after 5, 10, and 20 days, respectively, using sewage microorganisms as an unacclimated seed culture. Based on these data, it is expected that di-n-butyl phthalate will be biochemically oxidized to a lesser extent than domestic sewage by biological treatment in POTWs.

Biological treatment in POTW is expected to remove di-n-butyl phthalate to a moderate degree.

Di-n-octyl phthalate(69). In addition to the general remarks and discussion on phthalate esters, specific information on di-n-octyl phthalate is provided. Di-n-octyl phthalate is not to be confused with the isomeric bis(2-ethylhexyl) phthalate which is commonly referred to in the plastics industry as DOP. Di-n-octyl phthalate is a liquid which boils at 220°C at 5 mm Hg. It is insoluble in water. Its molecular formula is $C_6H_4(COOC_8H_{17})_2$. Its production constitutes about one percent of all phthalate ester production in the U.S.

Industrially, di-n-octyl phthalate is used to plasticize polyvinyl chloride (PVC) resins.

No ambient water criterion is proposed for di-n-octyl phthalate.

Biological treatment in POTW is expected to lead to little or no removal of di-n-octyl phthalate.

Diethyl phthalate (70). In addition to the general remarks and discussion on phthalate esters, specific information on diethyl phthalate is provided. Diethyl phthalate, or DEP, is a colorless liquid boiling at 296°C, and is insoluble in water. Its molecular formula is $C_6H_4(COOC_2H_5)_2$. Production of diethyl phthalate constitutes about 1.5 percent of phthalate ester production in the U.S.

Diethyl phthalate is approved for use in plastic food containers by the U.S. FDA. In addition to its use as a polyvinylchloride (PVC) plasticizer, DEP is used to plasticize cellulose nitrate for gun powder, to dilute polysulfide dental impression materials, and as an accelerator for dying triacetate fibers. An additional use which would contribute to its wide distribution in the environment is as an approved special denaturant for ethyl alcohol. The alcohol-containing products for which DEP is an approved denaturant include a wide range of personal care items such as bath preparations, bay rum, colognes, hair preparations, face and hand creams, perfumes and toilet soaps. Additionally, this denaturant is approved for use in biocides, cleaning solutions, disinfectants, insecticides, fungicides, and room deodorants which have ethyl alcohol as part of the formulation. It is expected, therefore, that people and buildings would have some surface loading of this priority pollutant which would find its way into raw wastewaters.

For the protection of human health from the toxic properties of diethyl phthalate ingested through water and through contaminated aquatic organisms, the ambient water criterion is determined to be 350 mg/l. If contaminated aquatic organisms alone are consumed, excluding the consumption of water, the ambient water criterion is 1800 mg/l.

Although the behavior of diethylphthalate in POTW has not been studied, biochemical oxidation of this priority pollutant has been studied on a laboratory scale at concentrations higher than would normally be expected in municipal wastewater. Biochemical oxidation of 79, 84, and 89 percent of theoretical was observed after 5, 5, and 20 days, respectively. Based on these data it is expected that diethyl phthalate will be biochemically oxidized to a lesser extent than domestic sewage by biological treatment in POTWs.

Dimethyl phthalate (71). In addition to the general remarks and discussion on phthalate esters, specific information on dimethyl phthalate (DMP) is provided. DMP has the lowest molecular weight of the phthalate esters - N.W. = 194 compared to M.W. of 391 for bis(2-ethylhexyl)phthalate. DMP has a boiling point of 282°C. It is a colorless liquid, soluble in water to the extent of 5 mg/l. Its molecular formula is $C_6H_4(COOCH_3)_2$.

Dimethyl phthalate production in the U.S. is just under one percent of total phthalate ester production. DMP is used to some extent as a plasticizer in cellulosics. However, its principle specific use is for dispersion of polyvinylidene fluoride (PVDF). PVDF is resistant to most chemicals and finds use as electrical insulation, chemical process equipment (particularly pipe), and as a base for long-life finishes for exterior metal siding. Coil coating techniques are used to apply PVDF dispersions to aluminum or galvanized steel siding.

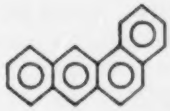
For the protection of human health from the toxic properties of dimethyl phthalate ingested through water and through contaminated aquatic organisms, the ambient water criterion is determined to be 313 mg/l. If contaminated aquatic organisms alone are consumed, excluding the consumption of water, the ambient water criterion is 2800 mg/l.

Based on limited data and observations relating molecular structure to ease of biochemical degradation of other organic pollutants, it is expected that dimethyl phthalate will be biochemically oxidized to a lesser extent than domestic sewage of biological treatment in POTWs.

Polynuclear Aromatic Hydrocarbons(72-84). The polynuclear aromatic hydrocarbons (PAH) selected as priority pollutants are a group of 13 compounds consisting of substituted and unsubstituted polycyclic aromatic rings. The general class of PAH includes hetrocyclics, but none of those were selected as priority pollutants. PAH are formed as the result of incomplete combustion when organic compounds are burned with insufficient oxygen. PAH are found in coke oven emissions, vehicular emissions, and volatile products of oil and gas burning. The compounds chosen as priority pollutants are listed with their structural formula and melting point (m.p.). All are insoluble in water.

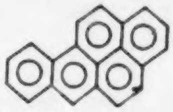
72 Benzo(a)anthrancene (1,2-benzanthracene)

m.p. 162°C



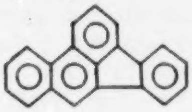
73 Benzo(a)pyrene (3,4-benzopyrene)

m.p. 176°C



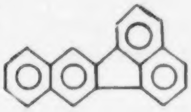
74 3,4-Benzofluoranthene

m.p. 168°C



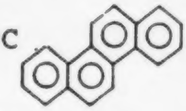
75 Benzo(k)fluoranthene (11,12-benzofluoranthene)

m.p. 217°C



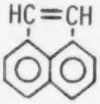
76 Chrysene (1,2-benzphenanthrene)

m.p. 255°C



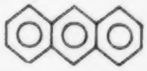
77 Acenaphthylene

m.p. 92°C



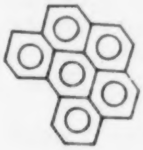
78 Anthracene

m.p. 216°C



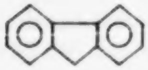
79 Benzo(ghi)perylene (1,12-benzoperylene)

m.p. not reported



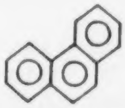
80 Fluorene (alpha-diphenylenemethane)

m.p. 116°C



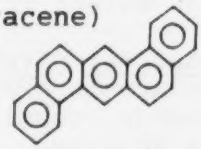
81 Phenanthrene

m.p. 101°C



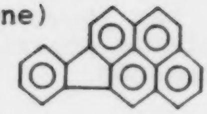
82 Dibenzo(a,h)anthracene (1,2,5,6-dibenzoanthracene)

m.p. 269°C



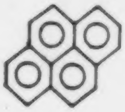
83 Indeno(1,2,3-cd)pyrene (2,3-o-phenyleneperylene)

m.p. not available



84 Pyrene

m.p. 156°C



Some of these priority pollutants have commercial or industrial uses. Benzo(a)anthracene, benzo(a)pyrene, chrysene, anthracene, dibenzo(a,h)anthracene, and pyrene are all used as antioxidants. Chrysene, acenaphthylene, anthracene, fluorene, phenanthrene, and pyrene are all used for synthesis of dyestuffs or other organic chemicals. 3,4-Benzofluoranthrene, benzo(k)fluoranthene, benzo(ghi)perylene, and indeno (1,2,3-cd)pyrene have no known industrial uses, according to the results of a recent literature search.

Several of the PAH priority pollutants are found in smoked meats, in smoke flavoring mixtures, in vegetable oils, and in coffee. They are found in soils and sediments in river beds. Consequently, they are also found in many drinking water supplies. The wide distribution of these pollutants in complex mixtures with the many other PAHs which have not been designated as priority pollutants results in exposures by humans that cannot be associated with specific individual compounds.

The screening and verification analysis procedures used for the organic priority pollutants are based on gas chromatography (GC). Three pairs of the PAH have identical elution times on the column specified in the protocol, which means that the pollutants of the pair are not differentiated. For these three pairs [anthracene (78) - phenanthrene (81); 3,4-benzofluoranthene (74) - benzo(k)fluoranthene (75); and benzo(a)anthracene (72) - chrysene (76)] results are obtained and reported as "either-or." Either both are present in the combined concentration reported, or one is present in the concentration reported. When detections below reportable limits are recorded no further analysis is required. For samples where the concentrations of coeluting pairs have a significant value, additional analyses are conducted, using different procedures that resolve the particular pair.

There are no studies to document the possible carcinogenic risks to humans by direct ingestion. Air pollution studies indicate an excess of lung cancer mortality among workers exposed to large amounts of PAH containing materials such as coal gas, tars, and coke-oven emissions. However, no definite proof exists that the PAH present in these materials are responsible for the cancers observed.

Animal studies have demonstrated the toxicity of PAH by oral and dermal administration. The carcinogenicity of PAH has been traced to formation of PAH metabolites which, in turn, lead to tumor formation. Because the levels of PAH which induce cancer are very low, little work has been done on other health hazards resulting from exposure. It has been established in animal studies that tissue damage and systemic toxicity can result from exposure to noncarcinogenic PAH compounds.

Because there were no studies available regarding chronic oral exposures to PAH mixtures, proposed water quality criteria were derived using data on exposure to a single compound. Two studies were selected, one involving benzo(a)pyrene ingestion and one involving dibenzo(a,h)anthracene ingestion. Both are known animal carcinogens.

For the maximum protection of human health from the potential carcinogenic effects of exposure to polynuclear aromatic hydro- carbons (PAH) through ingestion of water and contaminated aquatic organisms, the ambient water concentration is zero. Concentrations of PAH estimated to result in additional lifetime cancer risk of 10^{-7}, 10^{-6}, and 10^{-5} are 2.8×10^{-7} mg/l, $2.8 \times a0^{-6}$ mg/l and 2.8×10^{-5} mg/l, respectively. If contaminated aquatic organisms alone are consumed, excluding the consumption of water, the water concentration should be less than 3.11×10^{-4} mg/l to keep the increased lifetime cancer risk below 10^{-5}. Available data show the adverse effects on aquatic life occur at concentrations higher than those cited for human health risk.

The behavior of PAH in POTW has received only a limited amount of study. It is reported that up to 90 percent of PAH entering a POTW will be retained in the sludge generated by conventional sewage treatment processes. Some of the PAH can inhibit bacterial growth when they are present at concentrations as low as 0.018 mg/l. Biological treatment in activated sludge units has been shown to reduce the concentration of phenanthrene and anthracene to some extent. However, a study of biochemcial oxidation of fluorene on a laboratory scale showed no degradation after 5, 10, and 20 days. On the basis of that study and studies of other organic priority pollutants, some general observations were made relating molecular structure to ease of degradation. Those observations lead to the conclusion that the 13 PAH selected to represent that group as priority pollutants will be removed only slightly or not at all by biological treatment methods in POTW. Based on their water insolubility and tendency to attach to sediment particles very little pass through of PAH to POTW effluent is expected.

No data are available at this time to support any conclusions about contamination of land by PAH on which sewage sludge containing PAH is spread.

Tetrachloroethylene(85). Tetrachloroethylene (CCl_2CCl_2), also called perchloroethylene and PCE, is a colorless nonflammable liquid produced mainly by two methods - chlorination and pyrolysis of ethane and propane, and oxychlorination of dichloroethane. U.S. annual production exceeds 300,000 tons. PCE boils at 121°C and has a vapor pressure of 19 mm Hg at 20°C. It is insoluble in water but soluble in organic solvents.

Approximately two-thirds of the U.S. production of PCE is used for dry cleaning. Textile processing and metal degreasing, in equal amounts consume about one-quarter of the U.S. production.

The principal toxic effect of PCE on humans is central nervous system depression when the compound is inhaled. Headache, fatigue, sleepiness, dizziness and sensations of intoxication are reported. Severity of effects increases with vapor concentration. High integrated exposure (concentration times duration) produces kidney and liver damage. Very limited data on PCE ingested by laboratory animals indicate liver damage occurs when PCE is administered by that route. PCE tends to distribute to fat in mammalian bodies.

One report found in the literature suggests, but does not conclude, that PCE is teratogenic. PCE has been demonstrated to be a liver carcinogen in B6C3-Fl mice.

For the maximum protection of human health from the potential carcinogenic effects of exposure to tetrachloroethylene through ingestion of water and contaminated aquatic organisms, the ambient water concentration is zero. Concentrations of tetrachloroethylene estimated to result in additional lifetime cancer risk levels of 10^{-7}, 10^{-6}, and 10^{-5} are 8×10^{-5} mg/l, 8×10^{-4} mg/l, and 8×10^{-3} mg/l respectively. If contaminated aquatic organisms alone are consumed, excluding the consumption of water, the water concentration should be less than 0.088 mg/l to keep the increased lifetime cancer risk below 10^{-5}. Available data show that adverse effects on aquatic life occur at concentrations higher than those cited for human health risks.

Few data were found regarding the behavior of PCE in POTW. Many of the organic priority pollutants have been investigated, at least in laboratory scale studies, at concentrations higher than those expected to be contained by most municipal wastewaters. General observations have been developed relating molecular structure to ease of degradation for all of the organic priority pollutants. Based on study of the limited data, it is expected that PCE will be biochemically oxidized to a lesser extent than domestic sewage by biological treatment in POTW. An EPA study of seven POTW revealed removals of 40 to 100 percent. Sludge concentrations of tetrachloroethylene ranged from 1×10^{-3} to 1.6 mg/l. Some PCE is expected to be volatilized in aerobic treatment processes and little, if any, is expected to pass through into the effluent from the POTW.

Toluene(86). Toluene is a clear, colorless liquid with a benzene like odor. It is a naturally occuring compound derived primarily from petroleum or petrochemical processes. Some toluene is obtained from the manufacture of metallurgical coke. Toluene is also referred to as totuol, methylbenzene, methacide, and phenymethane. It is an aromatic hydrocarbon with the formula $C_6H_5CH_3$. It boils at 111°C and has a vapor pressure of 30 mm Hg at room temperature. The water solubility of toluene is 535 mg/l, and it is miscible with a variety of organic solvents. Annual production of toluene in the U.S. is greater than 2 million metric tons. Approximately two-thirds of the toluene is converted to benzene and the remaining 30 percent is divided approximately equally into chemical manufacture, and use as a paint solvent and aviation gasoline additive. An estimated 5,000 metric tons is discharged to the environment annually as a constituent in wastewater.

Most data on the effects of toluene in human and other mammals have been based on inhalation exposure or dermal contact studies. There appear to be no reports of oral administration of toluene to human subjects. A long term toxicity study on female rats revealed no adverse effects on growth, mortality, appearance and behavior, organ to body weight ratios, blood-urea nitrogen levels, bone marrow counts, peripheral blood counts, or morphology of major organs. The effects of inhaled toluene on the central nervous system, both at high and low concentrations, have been studied in humans and animals. However, ingested toluene is expected to be handled differently by the body because it is absorbed more slowly and must first pass through the liver before reaching the nervous system. Toluene is extensively and rapidly metabolized in the liver. One of the principal metabolic products of toluene is benzoic acid, which itself seems to have little potential to produce tissue injury.

Toluene does not appear to be teratogenic in laboratory animals or man. Nor is there any conclusive evidence that toluene is mutagenic. Toluene has not been demonstrated to be positive in any in vitro mutagenicity or carcinogenicity bioassay system, nor to be carcinogenic in animals or man.

Toluene has been found in fish caught in harbor waters in the vicinity of petroleum and petrochemical plants. Bioconcentration studies have not been conducted, but bioconcentration factors have been calculated on the basis of the octanol-water partition coefficient.

For the protection of human health from the toxic properties of toluene ingested through water and through contaminated aquatic organisms, the ambient water criterion is determined to be 14.3 mg/l. If contaminated aquatic organisms alone are consumed, excluding the consumption of water, the ambient water quality criterion is 424 mg/l. Available data show that adverse effects on aquatic life occur at concentrations as low as 5 mg/l.

Acute toxicity tests have been conducted with toluene and a variety of freshwater fish and Daphnia magna. The latter appears to be significantly more resistant than fish. No test results have been reported for the chronic effects of toluene on freshwater fish or invertebrate species.

Only one study of toluene behavior in POTW is available. However, the biochemical oxidation of many of the priority pollutants has been investigated in laboratory scale studies at con- centrations greater than those expected to be contained by most municipal wastewaters. At toluene concentrations ranging from 3 to 250 mg/l biochemical oxidation proceeded to fifty percent of theroetical or greater. The time period varied from a few hours to 20 days depending on whether or not the seed culture was acclimated. Phenol adapted acclimated seed cultures gave the most rapid and extensive biochemical oxidation. Based on study of the limited data, it is expected that toluene will be biochemically oxidized to a lesser extent than domestic sewage by biological treatment in POTW. The volatility and relatively low water solubility of toluene lead to the expectation that aeration processes will remove significant quantities of toluene from the POTW. The EPA studied toluene removal in seven POTW. The removals ranged from 40 to 100 percent. Sludge concentrations of toluene ranged from 54×10^{-3} to 1.85 mg/l.

Antimony(114). Antimony (chemical name - stibium, symbol Sb) classified as a nonmetal or metalloid, is a silvery white , brittle, crystalline solid. Antimony is found in small ore bodies throughout the world. Principal ores are oxides of mixed antimony valences, and an oxysulfide ore. Complex ores with metals are important because the antimony is recovered as a by-product. Antimony melts at 631°C, and is a poor conductor of electricity and heat.

Annual U.S. consumption of primary antimony ranges from 10,000 to 20,000 tons. About half is consumed in metal products - mostly antimonial lead for lead acid storage batteries, and about half in non - metal products. A principal compound is antimony trioxide which is used as a flame retardant in fabrics, and as an opacifier in glass, ceramincs, and enamels. Several antimony compounds are used as catalysts in organic chemicals synthesis, as fluorinating agents (the antimony fluoride), as pigments, and in fireworks. Semiconductor applications are economically significant.

Essentially no information on antimony - induced human health effects has been derived from community epidemiolocy studies. The available data are in literature relating effects observed with therapeutic or medicinal uses of antimony compounds and industrial exposure studies. Large therapeutic doses of antimonial compounds, usually used to treat schistisomiasis, have caused severe nausea, vomiting, convulsions, irregular heart action, liver damage, and skin rashes. Studies of acute industrial antimony poisoning have revealed loss of appetitie, diarrhea, headache, and dizziness in addition to the symptoms found in studies of therapeutic doses of antimony.

For the protection of human health from the toxic properties of antimony ingested through water and through contaminated aquatic organisms the ambient water criterion is determined to be 0.146 mg/l. If contaminated aquatic organisms alone are consumed, excluding the consumption of water, the ambient water criterion is determined to be 45 mg/l. Available data show that adverse effects on aquatic life occur at concentrations higher than those cited for human health risks.

Very little information is available regarding the behavior of antimony in POTW. The limited solubility of most antimony compounds expected in POTW, i.e. the oxides and sulfides, suggests that at least part of the antimony entering a POTW will be precipitated and incorporated into the sludge. However, some antimony is expected to remain dissolved and pass through the POTW into the effluent. Antimony compounds remaining in the sludge under anaerobic conditions may be connected to stibine (SbH_3), a very soluble and very toxic compound. There are no data to show antimony inhibits any POTW processes. Antimony is not known to be essential to the growth of plants, and has been reported to be moderately toxic. Therefore, sludge containing large amounts of antimony could be detrimental to plants if it is applied in large amounts to cropland.

Arsenic(115). Arsenic (chemical symbol As), is classified as a nonmetal or metalloid. Elemental arsenic normally exists in the alpha-crystalline metallic form which is steel gray and brittle, and in the beta form which is dark gray and amorphous. Arsenic sublimes at 615°C. Arsenic is widely distributed throughout the world in a large number of minerals. The most important commercial source of arsenic is as a by-product from treatment of copper, lead, cobalt, and gold ores. Arsenic is usually marketed as the trioxide (As_2O_3). Annual U.S. production of the trioxide approaches 40,000 tons.

The principal use of arsenic is in agricultural chemicals (herbicides) for controlling weeds in cotton fields. Arsenicals have various applications in medicinal and veterinary use, as wood preservatives, and in semiconductors.

The effects of arsenic in humans were known by the ancient Greeks and Romans. The principal toxic effects are gastrointestinal disturbances. Breakdown of red blood cells occurs. Symptoms of acute poisoning include vomiting, diarrhea, abdominal pain, lassitude, dizziness, and headache. Longer exposure produced dry, falling hair, brittle, loose nails, eczema; and exfoliation. Arsenicals also exhibit teratogenic and mutagenic effects in humans. Oral administration of arsenic compounds has been associated clinically with skin cancer for nearly a hundred years. Since 1888 numerous studies have linked occupational exposure to, and therapeutic administration of arsenic compounds to increased incidence of respiratory and skin cancer.

For the maximum protection of human health from the potential carcinogenic effects of exposure to arsenic through ingestion of water and contaminated aquatic organisms, the ambient water concentration is zero. Concentrations of arsenic estimated to result in additional lifetime cancer risk levels of 10^{-7}, 10^{-6}, and 10^{-5} are 2.2×10^{-7} mg/l, 2.2×10^{-6} mg/l, and 2.2×10^{-5} mg/l, respectively. If contaminated aquatic organisms alone are consumed, excluding the consumption of water, the water concentration should be less than 2.7×10^{-4} mg/l to keep the increased lifetime cancer risk below 10^{-5}. Available data show that adverse effects on aquatic life occur at concentrations higher than those cited for human health risks.

A few studies have been made regarding the behavior of arsenic in POTW. One EPA survey of 9 POTW reported influent concentrations ranging from 0.0005 to 0.693 mg/l; effluents from 3 POTW having biological treatment contained 0.0004 - 0.01 mg/l; 2 POTW showed arsenic removal efficiencies of 50 and 71 percent in biological treatment. Inhibition of treatment processes by sodium arsenate is reported to occur at 0.1 mg/l in activated sludge, and 1.6 mg/l in anaerobic digestion processes. In another study based on data from 60 POTW, arsenic in sludge ranged from 1.6 to 65.6 mg/kg and the median value was 7.8 mg/kg. Arsenic in sludge spread on cropland may be taken up by plants grown on that land. Edible palnts can take up arsenic, but normally their growth is inhibited before the palnts are ready for harvest.

Cadmium(118). Cadmium is a relatively rare metallic element that is seldom found in sufficient quantities in a pure state to warrant mining or extraction from the earth's surface. It is found in trace amounts of about 1 ppm throughout the earth's crust. Cadmium is, however, a valuable by-product of zinc production.

Cadmium is used primarily as an electroplated metal, and is found as an impurity in the secondary refining of zinc, lead, and copper.

Cadmium is an extremely dangerous cumulative toxicant, causing progressive chronic poisoning in mammals, fish, and probably other organisms. The metal is not excreted.

Toxic effects of cadmium on man have been reported from throughout the world. Cadmium may be a factor in the development of such human pathological conditions as kidney disease, testicular tumors, hypertension, arteriosclerosis, growth inhibition, chronic disease of old age, and cancer. Cadmium is normally ingested by humans through food and water as well as by breathing air contaminated by cadmium dust. Cadmium is cumulative in the liver, kidney, pancreas, and thyroid of humans and other animals. A severe bone and kidney syndrome known as itai-itai disease has been documented in Japan as caused by cadmium ingestion via drinking water and contaminated irrigation water. Ingestion of as little as 0.6 mg/day has produced the disease. Cadmium acts synergistically with other metals. Copper and zinc substantially increase its toxicity.

Cadmium is concentrated by marine organisms, particularly mollusks, which accumulate cadmium in calcareous tissues and in the viscera. A concentration factor of 1000 for cadmium in fish muscle has been reported, as have concentration factors of 3000 in marine plants and up to 29,600 in certain marine animals. The eggs and larvae of fish are apparently more sensitive than adult fish to poisoning by cadmium, and crustaceans appear to be more sensitive than fish eggs and larvae.

For the protection of human health from the toxic properties of cadmium ingested through water and through contaminated aquatic organisms, the ambient water criterion is determined to be 0.010 mg/l. Available data show that adverse effects on aquatic life occur at concentrations in the same range as those cited for human health, and they are highly dependent on water hardness.

Cadmium is not destroyed when it is introduced into a POTW, and will either pass through to the POTW effluent or be incorporated into the POTW sludge. In addition, it can interfere with the POTW treatment process.

In a study of 189 POTW, 75 percent of the primary plants, 57 percent of the trickling filter plants, 66 percent of the activated sludge plants and 62 percent of the biological plants allowed over 90 percent of the influent cadmium to pass thorugh to the POTW effluent. Only 2 of the 189 POTW allowed less than 20 percent pass-through, and none less than 10 percent pass-through. POTW effluent concentrations ranged from 0.001 to 1.97 mg/l (mean 0.028 mg/l, standard deviation 0.167 mg/l).

Cadmium not passed through the POTW will be retained in the sludge where it is likely to build up in concentration. Cadmium contamination of sewage sludge limits its use on land since it increases the level of cadmium in the soil. Data show that cadmium can be incorporated into crops, including vegetables and grains, from contaminated soils. Since the crops themselves show no adverse effects from soils with levels up to 100 mg/kg cadmium, these contaminated crops could have a significant impact on human health. Two Federal agencies have already recognized the potential adverse human health effects posed by the use of sludge on cropland. The FDA recommends that sludge containing over 30 mg/kg of cadmium should not be used on agricultural land. Sewage sludge contains 3 to 300 mg/kg (dry basis) of cadmium mean = 10 mg/kg; median = 16 mg/kg. The USDA also recommends placing limits on the total cadmium from sludge that may be applied to land.

Chromium(119). Chromium is an elemental metal usually found as a chromite ($FeO \bullet Cr_2O_3$). The metal is normally produced by reducing the oxide with aluminum. A significant proportion of the chromium used is in the form of compounds such as sodium dichromate (Na_2CrO_4), and chromic acid (CrO_3) - both are hexavalent chromium compounds.

Chromium is found as an alloying component of many steels and its compounds are used in electroplating baths, and as corrosion inhibitors for closed water circulation systems.

The two chromium forms most frequently found in industry wastewaters are hexavalent and trivalent chromium. Hexavalaent chromium is the form used for metal treatments. Some of it is reduced to trivalent chromium as part of the process reaction. The raw wastewater containing both valence states is usually treated first to reduce remaining hexavalent to trivalent chromium, and second to precipitate the trivalent form as the hydroxide. The hexavalent form is not removed by lime treatment.

Chromium, in its various valence states, is hazardous to man. It can produce lung tumors when inhaled, and induces skin sensitizations. Large doses of chromates have corrosive effects on the intestinal tract and can cause inflammation of the kidneys. Hexavalent chromium is a known human carcinogen. Levels of chromate ions that show no effect in man appear to be so low as to prohibit determination, to date.

The toxicity of chromium salts to fish and other aquatic life varies widely with the species, temperature, pH, valence of the chromium, and synergistic or antagonistic effects, especially the effect of water hardness. Studies have shown that trivalent chromium is more toxic to fish of some types than is hexavalent chromium. Hexavalent chromium retards growth of one fish species at 0.0002 mg/l. Fish food organisms and other lower forms of aquatic life are extremely sensitive to chromium. Therefore, both hexavalent and trivalent chromium must be considered harmful to particular fish or organisms.

For the protection of human health from the toxic properties of chromium (except hexavalent chromium) ingested through water and contaminated aquatic organisms, the ambient water criterion is 0.050 mg/l. For the maximum protection of human health from the potential carcinogenic effects of exposure to hexavalent chromium through ingestion of water and contaminated aquatic organisms, the ambient water concentration is zero. The estimated levels which would result in increased lifetime cancer risks of 10^{-7}, 10^{-6}, and 10^{-5} are 7.4 x 10^{-8} mg/l, 7.4 x 10^{-7} mg/l, and 7.4 x 10^{-6} mg/l respectively. If contaminated aquatic organisms alone are consumed, excluding the consumption of water, the water concentration should be less than 1.5 x 10^{-5} mg/l to keet the increased lifetime cancer risk below 10^{-5}.

Chromium is not destroyed when treated by POTW (although the oxidation state may change), and will either pass through to the POTW effluent or be incorporated into the POTW sludge. Both oxidation states can cause POTW treatment inhibition and can also limit the usefuleness of municipal sludge.

Influent concentrations of chromium to POTW facilities have been observed by EPA to range from 0.005 to 14.0 mg/l, with a median concentration of 0.1 mg/l. The efficiencies for removal of chromium by the activated sludge process can vary greatly, depending on chromium concentration in the influent, and other operating conditions at the POTW. Chelation of chromium by organic matter and dissolution due to the presence of carbonates can cause deviations from the predicted behavior in treatment systems.

The systematic presence of chromium compounds will halt nitrification in a POTW for short periods, and most of the chromium will be retained in the sludge solids. Hexavalent chromium has been reported to severely affect the nitrification process, but trivalent chromium has litte or no toxicity to activated sludge, except at high concentrations. The presence of iron, copper, and low pH will increase the toxicity of chromium in a POTW by releasing the chromium into solution to be ingested by microorganisms in the POTW.

The amount of chromium which passes through to the POTW effluent depends on the type of treatment processes used by the POTW. In a study of 240 POTWs 56 percent of the primary plants allowed more than 80 percent pass through to POTW effluent. More advanced treatment results in less pass-through. POTW effluent concentrations ranged from 0.003 to 3.2 mg/l total chromium (mean = 0.197, standard deviation = 0.48), and from 0.002 to 0.1 mg/l hexavalent chromium (mean = 0.017, standard deviation = 0.020).

Chromium not passed through the POTW will be retained in the sludge, where it is likely to build up in concentration. Sludge concentrations of total chromium of over 20,000 mg/kg (dry basis) have been observed. Disposal of sludges containing very high concentrations of trivalent chromium can potentially cause problems in uncontrollable landfills. Incineration, or similar destructive oxidation processes can produce hexavalent chromium from lower valance states. Hexavalent chromium is potentially more toxic than trivalent chromium. In cases where high rates of chrome sludge application on land are used, distinct growth inhibition and plant tissue uptake have been noted.

Pretreatment of discharges substantially reduces the concentration of chromium in sludge. In Buffalo, New York, pretreatment of electroplating waste resulted in a decrease in chromium concentrations in POTW sludge from 2,510 to 1,040 mg/kg. A similar reduction occurred in in Grand Rapids, Michigan POTW where the chromium concentration in sludge decreased from 11,000 to 2,700 mg/kg when pretreatment was made a requirement.

Copper(120). Copper is a metallic element that sometimes is found free, as the native metal, and is also found in minerals such as cuprite (Cu_2O), malechite [$CuCO_3 \bullet Cu(OH)_2$], azurite [$2CuCO_3 \bullet Cu(OH)_2$], chalcopyrite ($CuFeS_2$), and bornite (Cu_5FeS_4). Copper is obtained from these ores by smelting, leaching, and electrolysis. It is used in the plating, electrical, plumbing, and heating equipment industries, as well as in insecticides and fungicides.

Traces of copper are found in all forms of plant and animal life, and the metal is an essential trace element for nutrition. Copper is not considered to be a cumulative systemic poison for humans as it is readily excreted by the body, but it can cause symptoms of gastroenteritis, with nausea and intestinal irritations, at relatively low dosages. The limiting factor in domestic water supplies is taste. To prevent this adverse organoleptic effect of copper in water, a criterion of 1 mg/l has been established.

The toxicity of copper to aquatic organisms varies significantly, not only with the species, but also with the physical and chemical characteristics of the water, including temperature, hardness, turbidity, and carbon dioxide content. In hard water, the toxicity of copper salts may be reduced by the precipitation of copper carbonate or other insoluble compounds. The sulfates of copper and zinc, and of copper and calcium are synergistic in their toxic effect on fish.

Relatively high concentrations of copper may be tolerated by adult fish for short periods of time; the critical effect of copper appears to be its higher toxicity to young or juvenile fish. Concentrations of 0.02 to 0.031 mg/l have proven fatal to some common fish species. In general the salmonoids are very sensitive and the sunfishes are less sensitive to copper.

The recommended criterion to protect saltwater aquatic life is 0.00097 mg/l as a 24-hour average, and 0.018 mg/l maximum concentration.

Copper salts cause undesirable color reactions in the food industry and cause pitting when deposited on some other metals such as aluminum and galvanized steel. To control undesirable taste and odor quality of ambient water due to the organoleptic properties of copper, the estimated level is 1.0 mg/l. For total recoverable copper the criterion to protect freshwater aquatic life is 5.6×10^{-3} mg/l as a 24 hour average.

Irrigation water containing more than minute quantities of copper can be detrimental to certain crops. Copper appears in all soils, and its concentration ranges from 10 to 80 ppm. In soils, copper occurs in association with hydrous oxides of manganese and iron, and also as soluble and insoluble complexes with organic matter. Copper is essential to the life of plants, and the normal range of concentration in plant tissue is from 5 to 20 ppm. Copper concentrations in plants normally do not build up to high levels when toxicity occurs. For example, the concentrations of copper in snapbean leaves and pods was less than 50 and 20 mg/kg, respectively, under conditions of severe copper toxicity. Even under conditions of copper toxicity, most of the excess copper accumulates in the roots; very little is moved to the aerial part of the plant.

Copper is not destroyed when treated by a POTW, and will either pass through to the POTW effluent or be retained in the POTW sludge. It can interfere with the POTW treatment processes and can limit the usefulness of municipal sludge.

The influent concentration of copper to POTW facilities has been observed by the EPA to range from 0.01 to 1.97 mg/l, with a median concentration of 0.12 mg/l. The copper that is removed from the influent stream of a POTW is adsorbed on the sludge or appears in the sludge as the hydroxide of the metal. Bench scale pilot studies have shown that from about 25 percent to 75 percent of the copper passing through the activated sludge process remains in solution in the final effluent. Four-hour slug dosages of copper sulfate in concentrations exceeding 50 mg/l were reported to have severe effects on the removal efficiency of an unacclimated system, with the system returning to normal in about 100 hours. Slug dosages of copper in the form of copper cyanide were observed to have much more severe effects on the activated sludge system, but the total system returned to normal in 24 hours.

In a recent study of 268 POTW, the median pass-through was over 80 percent for primary plants and 40 to 50 percent for trickling filter, activated sludge, and biological treatment plants. POTW effluent concentrations of copper ranged from 0.003 to 1.8 mg/l (mean 0.126, standard deviation 0.242).

Copper which does not pass through the POTW will be retained in the sludge where it will build up in concentration. The presence of excessive levels of copper in sludge may limit its use on cropland. Sewage sludge contains up to 16,000 mg/kg of copper, with 730 mg/kg as the mean value. These concentrations are significantly greater than those normally found in soil, which usually range from 18 to 80 mg/kg. Experimental data indicate that when dried sludge is spread over tillable land, the copper tends to remain in place down to the depth of tillage, except for copper which is taken up by plants grown in the soil. Recent investigation has shown that the extractable copper content of sludge-treated soil decreased with time, which suggests a reversion of copper to less soluble forms was occurring.

Cyanide(121). Cyanides are among the most toxic of pollutants commonly observed in industrial wastewaters. Introduction of cyanide into industrial processes is usually by dissolution of potassium cyanide (KCN) or sodium cyanide (NaCN) in process waters. However, hydrogen cyanide (HCN) formed when the above salts are dissolved in water, is probably the most acutely lethal compound.

The relationslhip of pH to hydrogen cyanide formation is very important. As pH is lowered to below 7, more than 99 percent of the cyanide is present as HCN and less than 1 percent as cyanide ions. Thus, at neutral pH, that of most living organisms, the more toxic form of cyanide prevails.

Cyanide ions combine with numerous heavy metal ions to form complexes. The complexes are in equilibrium with HCN. Thus, the stability of the metal-cyanide complex and the pH determine the concentration of HCN. Stability of the metal-cyanide anion complexes is extremely variable. Those formed with zinc, copper, and cadmium are not stable - they rapidly dissociate, with production of HCN, in near neutral or acid waters. Some of the complexes are extremely stable. Cobaltocyanide is very resistant to acid distillation in the laboratory. Iron cyanide complexes are also stable, but undergo photodecomposition to give HCN upon exposure to sunlight. Synergistic effects have been demonstrated for the metal cyanide complexes making zinc, copper, and cadmiun, cyanides more toxic than an equal concentration of sodium cyanide.

The toxic mechanism of cyanide is essentially an inhibition of oxygen metabolism, i.e., rendering the tissues incapable of exchanging oxygen. The cyanogen compounds are true noncummulative protoplasmic poisons. They arrest the activity of all forms of animal life. Cyanide shows a very specific type of toxic action. It inhibits the cytochrome oxidase system. This system is the one which facilitates electron transfer from reduced metabolites to molecular oxygen. The human body can convert cyanide to a nontoxic thiocyanate and elminiate it. However, if the quantity of cyanide ingested is too great at one time, the inhibition of oxygen utilization proves fatal before the detoxifying reaction reduces the cyanide con- centration to a safe level.

Cyanides are more toxic to fish than to lower forms of aquatic organisms such as midge larvae, crustaceans, and mussels. Toxicity to fish is a function of chemical form and con- centration, and is influenced by the rate of metabolism (temperature), the level of dissolved oxygen, and pH. In laboratory studies free cyanide concentrations ranging from 0.05 to 0.15 mg/l have been proven to be fatal to sensitive fish species including trout, bluegill, and fathead minnows. Levels above 0.2 mg/l are rapidly fatal to most fish species. Long term sublethal concentrations of cyanide as low as 0.01 mg/l have been shown to affect the ability of fish to function normally, e.g., reproduce, grow, and swim.

For the protection of human health from the toxic properties of cyanide ingested through water and through contaminated aquatic organisms, the ambient water criterion is determined to be 0.200 mg/l.

Available data show taht adverse effects on aquatic life occur at concentrations as low as 3.5×10^{-3} mg/l.

Presistance of cyanide in water is highly variable and depends upon the chemical form of cyanide in the water, the concentration of cyanide, and the nature of other constituents. Cyanide may be destroyed by strong oxidizing agents such as permanganate and chlorine. Chlorine is commonly used to oxidize strong cyanide solutions. Carbon dioxide and nitrogen are the products of complete oxidation. But if the reaction is not complete, the very toxic compound, cyanogen chloride, may remain in the treatment system and subsequently be released to the environment. Partial chlorination may occur as part of a POTW treatment, or during the disinfection treatment of surface water for drinking water preparation.

Cyanides can interfere with treatment processes in POTW, or pass through to ambient waters. At low concentrations and with acclimated microflora, cyanide may be decomposed by microorganisms in anaerobic and aerobic environments or waste treatment systems. However, data indicate that much of the cyanide introduced passes through to the POTW effluent. The mean pass-through of 14 biological plants was 71 percent. In a recent study of 41 POTW the effluent concentrations ranged from 0.002 to 100 mg/l (mean = 2.518, standard deviation = 15.6). Cyanide also enhances the toxicity of metals commonly found in POTW effluents, including the priority pollutants cadmium, zinc, and copper.

Data for Grand Rapids, Michigan, showed a significant decline in cyanide concentrations downstream from the POTW after pretreat- ment regulations were put in force. Concentrations fell from 0.66 mg/l before, to 0.01 mg/l after pretreatment was required.

Lead (122). Lead is a soft, malleable, ductible, blueish-gray, metallic element, usually obtained from the mineral galena (lead sulfide, PbS), anglesite (lead sulfate, $PbSO_4$), or cerussite (lead carbonate, $PbCO_3$). Because it is usually associated with minerals of zinc, silver, copper, gold, cadmium, antimony, and arsenic, special purification methods are frequently used before and after extraction of the metal from the ore concentrate by smelting.

Lead is widely used for its corrosion resistance, sound and vibration absorption, low melting point (solders), and relatively high imperviousness to various forms of radiation. Small amounts of copper, antimony and other metals can be alloyed with lead to achieve greater hardness, stiffness, or corrosion resistance than is afforded by the pure metal. Lead compounds are used in glazes and paints. About one third of U.S. lead consumption goes into storage batteries. About half of U.S. lead consumption is from secondary lead recovery. U.S. consumption of lead is in the range of one million tons annually.

Lead ingested by humans produces a variety of toxic effects including impaired reproductive ability, disturbances in blood chemistry, neurological disorders, kidney damage, and adverse cardiovascular effects. Exposure to lead in the diet results in permanent increase in lead levels in the body. Most of the lead entering the body eventually becomes localized in the bones where it accumulates. Lead is a carcinogen or cocarcinogen in some species of experimental animals. Lead is teratogenic in experimental animals. Mutangenicity data are not available for lead.

For the protection of human health from the toxic properties of lead ingested through water and through contaminated aquatic organisms, the ambient water criterion is 0.050 mg/l. Available data show that adverse effects on aquatic life occur at concentrations as low as 7.5 x 10^{-4} mg/l.

Lead is not destroyed in POTW, but is passed through to the effluent or retained in the POTW sludge; it can interfere with POTW treatment processes and can limit the usefulness of POTW sludge for application to agricultural croplands. Threshold concentration for inhibition of the activated sludge process is 0.1 mg/l, and for the nitrification process is 0.5 mg/l. In a study of 214 POTW, median pass through values were over 80 percent for primary plants and over 60 percent for trickling filter, activated sludge, and biological process plants. Lead concentration in POTW effluents ranged from 0.003 to 1.8 mg/l (means = 0.106 mg/l, standard deviation = 0.222).

Application of lead-containing sludge to cropland should not affect the uptake by crops under most conditions because normally lead is strongly bound by soil. However, under the unusual conditions of low pH (less than 5.5) and low concentrations of labile phosphorus, lead solubility is increased and plants can accumulate lead.

Nickel(124). Nickel is seldom found in nature as the pure elemental metal. It is a reltively plentiful element and is widely distributed throughout the earth's crust. It occurs in marine organisms and is found in the oceans. The chief commercial ores for nickel are pentlandite $[(Fe,Ni)_9S_8]$, and a lateritic ore consisting of hydrated nickel-iron-magnesium silicate.

Nickel has many and varied uses. It is used in alloys and as the pure metal. Nickel salts are used for electroplating baths.

The toxicity of nickel to man is thought to be very low, and systemic poisoning of human beings by nickel or nickel salts is almost unknown. In nonhuman mammals nickel acts to inhibit insulin release, depress growth, and reduce cholesterol. A high incidence of cancer of the lung and nose has been reported in humans engaged in the refining of nickel.

Nickel salts can kill fish at very low concentrations. However, nickel has been found to be less toxic to some fish than copper, zinc, and iron. Nickel is present in coastal and open ocean water at concentrations in the range of 0.0001 to 0.006 mg/l although the most common values are 0.002 - 0.003 mg/l. Marine animals contain up to 0.4 mg/l and marine plants contain up to 3 mg/l. Higher nickel concentrations have been reported to cause reduction in photosynthetic activity of the giant kelp. A low concentration was found to kill oyster eggs.

For the protection of human health based on the toxic properties of nickel ingested through water and through contaminated aquatic organisms, the ambient water criterion is determined to be 0.134 mg/l. If contaminated aquatic organisms are consumed, excluding consumption of water, the ambient water criterion is determined to be 1.01 mg/l. Available data show that adverse effects on aquatic life occur for total recoverable nickel concentrations as low as 0.032 mg/l.

Nickel is not destroyed when treated in a POTW, but will either pass through to the POTW effluent or be retained in the POTW sludge. It can interfere with POTW treatment processes and can also limit the usefulness of municipal sludge.

Nickel salts have caused inhibition of the biochemical oxidation of sewage in a POTW. In a pilot plant, slug doses of nickel significantly reduced normal treatment efficiencies for a few hours, but the plant acclimated itself somewhat to the slug dosage and appeared to achieve normal treatment efficiencies within 40 hours. It has been reported that the anaerobic digestion process is inhibited only by high concentrations of nickel, while a low concentration of nickel inhibits the nitrification process.

The influent concentration of nickel to POTW facilities has been observed by the EPA to range from 0.01 to 3.19 mg/l, with a median of 0.33 mg/l. In a study of 190 POTW, nickel pass-through was greater than 90 percent for 82 percent of the primary plants. Median pass-through for trickling filter, activated sludge, and biological process plants was greater than 80 percent. POTW effuent concentrations ranged from 0.002 to 40 mg/l (mean = 0.410, standard deviation = 3.279).

Nickel not passed through the POTW will be incorporated into the sludge. In a recent two-year study of eight cities, four of the cities had median nickel concentrations of over 350 mg/kg, and two were over 1,000 mg/kg. The maximum nickel concentration observed was 4,010 mg/kg.

Nickel is found in nearly all soils, plants, and waters. Nickel has no known essential function in plants. In soils, nickel typically is found in the range from 10 to 100 mg/kg. Various environmental exposures to nickel appear to correlate with increased incidence of tumors in man. For example, cancer in the maxillary antrum of snuff users may result from using plant material grown on soil high in nickel.

Nickel toxicity may develop in plants from application of sewage sludge on acid soils. Nickel has caused reduction of yields for a variety of crops including oats, mustard, turnips, and cabbage. In one study nickel decreased the yields of oats significantly at 100 mg/kg.

Whether nickel exerts a toxic effect on plants depends on several soil factors, the amount of nickel applied, and the contents of other metals in the sludge. Unlike copper and zinc, which are more available from inorganic sources than from sludge, nickel uptake by plants seems to be promoted by the presence of the organic matter in sludge. Soil treatments, such as liming reduce the solubility of nickel. Toxicity of nickel to plants is enhanced in acidic soils.

Selenium(125). Selenium (chemical symbol Se) is a nonmetallic element existing in several allotropic forms. Gray selenium, which has a metallic appearance, is the stable form at ordinary temperatures and melts at 220°C. Selenium is a major component of 38 minerals and a minor component of 37 others found in various parts of the world. Most selenium is obtained as a by-product of precious metals recovery from electrolytic copper refinery slimes. U.S. annual production at one time reached one million pounds.

Principal uses of selenium are in semi-conductors, pigments, decoloring of glass, zerography, and metallurgy. It also is used to produce ruby glass used in signal lights. Several selenium compounds are important oxidizing agents in the synthesis of organic chemicals and drug products.

While results of some studies suggest that selenium may be an essential element in human nutrition, the toxic effects of selenium in humans are well established. Lassitude, loss of hair, discoloration and loss of fingernails are symptoms of selenium poisoning. In a fatal case of ingestion of a larger dose of selenium acid, peripheral vascular collapse, pulumonary edema, and coma occurred. Selenium produces mutagenic and teratogenic effects, but it has not been established as exhibiting carcinogenic activity.

For the protection of human health from the toxic properties of selenium ingested through water and through contaminated aquatic organisms, the ambient water criterion is determind to be 0.010 mg/l. Available data show that adverse effects on aquatic life occur at concentrations higher than that cited for human toxicity.

Very few data are available regarding the behavior of selenium in POTW. One EPA survey of 103 POTW revealed one POTW using biological treatment and having selenium in the influent. Influent concentration was 0.0025 mg/l, effluent concentration was 0.0016 mg/l giving a removal of 37 percent. It is not known to be inhibitory to POTW processes. In another study, sludge from POTW in 16 cities was found to contain from 1.8 to 8.7 mg/kg selenium, compared to 0.01 to 2 mg/kg in untreated soil. These concentrations of selenium in sludge present a potential hazard for humans or other mammuals eating crops grown on soil treated with selenium containing sludge.

Silver(126). Silver is a soft, lustrous, white metal that is insoluble in water and alkali. In nature, silver is found in the elemental state (native silver) and combined in ores such as argentite (Ag_2S), horn silver ($AgCl$), proustite (Ag_3AsS_3), and pyrargyrite (Ag_3SbS_3). Silver is used extensively in several industries, among them electroplating.

Metallic silver is not considered to be toxic, but most of its salts are toxic to a large number of organisms. Upon ingestion by humans, many silver salts are absorbed in the circulatory system and deposited in various body tissues, resulting in generalized or sometimes localized gray pigmentation of the skin and mucous membranes know as argyria. There is no known method for removing silver from the tissues once it is deposited, and the effect is cumulative.

Silver is recognized as a bactericide and doses from 1×10^{-6} to 5×10^{-4} mg/l have been reported as sufficient to sterilize water. The ambient water criterion to protect human health from the toxic properties of silver ingested through water and through contaminated aquatic organisms is 0.05 mg/l. Available data show that adverse effects on aquatic life occur at total recoverable silver concentrations as low as 1.2×10^{-3} mg/l.

The chronic toxic effects of silver on the aquatic environment have not been given as much attention as many other heavy metals. Data from existing literature support the fact that silver is very toxic to aquatic organisms. Despite the fact that silver is nearly the most toxic of the heavy metals, there are insufficient data to adequately evaluate even the effects of hardness on silver toxicity. There are no data available on the toxicity of different forms of silver.

There is no available literature on the incidental removal of silver by POTW. An incidental removal of about 50 percent is assumed as being representative. This is the highest average incidental removal of any metal for which data are available. (Copper has been indicated to have a median incidental removal rate of 49 percent).

Bioaccumulation and concentration of silver from sewage sludge has not been studied to any great degree. There is some indication that silver could be bioaccumulated in mushrooms to the extent that there could be adverse physiological effects on humans if they consumed large quantites of mushrooms grown in silver enriched soil. The effect, however, would tend to be unpleasnat rather than fatal.

There is little summary data available on the quantity of silver discharged to POTW. Presumably there would be a tendency to limit its discharge from a manufacturing facility because of its high intrinsic value.

Thallium (127). Thallium (Tl) is a soft, silver-white, dense, malleable metal. Five major minerals contain 15 to 85 percent thallium, but they are not of commerical importance because the metal is produced in sufficient quantity as a by-product of lead-zinc smelting of sulfide ores. Thallium melts at 304°C. U.S. annual production of thallium and its compounds is estimated to be 1500 lb.

Industrial uses of thallium include the manufacture of alloys, electronic devices and special glass. Thallium catalysts are used for industrial organic syntheses.

Acute thallium poisoning in humans has been widely described. Gastrointestinal pains and diarrhea are followed by abnormal sensation in the legs and arms, dizziness, and, later, loss of hair. The central nervous system is also affected. Somnolence, delerium or coma may occur. Studies on the teratogenicity of thallium appear inconclusive; no studies on mutagenicity were found; and no published reports on carcinogenicity of thallium were found.

For the protection of human health from the toxic properties of thallium ingested through water and contaminated aquatic organisms, the ambient water criterion is 1.34 x 10^{-2} mg/l. If contaminated aquatic organisms alone are consumed, excluding consumption of water, the ambient water criterion is determined to be 48 mg/l. Available data show that adverse effects on aquatic life occur at concentrations higher than those cited for human health risks.

No reports were found regarding the behavior of thallium in POTW. It will not be degraded, therefore it must pass through to the effluent or be removed with the sludge. However since the sulfide (TlS) is very insoluble, if appreciable sulfide is present dissolved thallium in the influent to POTW may be precipitated into the sludge. Subsequent use of sludge bearing thallium compounds as a soil amendment to crop bearing soils may result in uptake of this element by food plants. Several leafy garden crops (cabbage, lettuce, leek, and endive) exhibit relatively higher concentrations of thallium than other foods such as meat.

Zinc(128). Zinc occurs abundantly in the earth's crust, concentrated in ores. It is readily refined into the pure, stable, silvery-white metal. In addition to its use in alloys, zinc is used as a protective coating on steel. It is applied by hot dipping (i.e. dipping the steel in molten zinc) or by electroplating.

Zinc can have an adverse effect on man and animals at high concentrations. Zinc at concentrations in excess of 5 mg/l causes an undesirable taste and odor which persists through conventional treatment. For the prevention of adverse effects due to these organoleptic properties of zinc, concentrations in ambient water should not exceed 5 mg/l. Available data show that adverse effects on aquatic life occur at concentrations as low as 0.047 mg/l.

Toxic concentrations of zinc compounds cause adverse changes in the morphology and physiology of fish. Lethal concentrations in the range of 0.1 mg/l have been reported. Acutely toxic concentrations induce cellular breakdown of the gills, and possibly the clogging of the gills with mucous. Chronically toxic concentrations of zinc compounds cause general enfeeblement and widespread histological changes to many organs, but not to gills. Abnormal swimming behavior has been reported at 0.04 mg/l. Growth and maturation are retarded by zinc. It has been observed that the effects of zinc poisoning may not become apparent immediately, so that fish removed from zinc-contaminated water may die as long as 48 hours after removal.

In general, salmonoids are most sensitive to elemental zinc in soft water; the rainbow trout is the most sensitive in hard waters. A complex relationship exists between zinc concentration, dissolved zinc concentration, pH, temperature, and calcium and magnesium concentration. Prediction of harmful effects has been less than reliable and controlled studies have not been extensively documented.

The major concern with zinc compounds in marine waters is not with acute lethal effects, but rather with the long-term sublethal effects of the metallic compounds and complexes. Zinc accumulates in some marine species, and marine animals contain zinc in the range of 6 to 1500 mg/kg. From the point of view of acute lethal effects, invertebrate marine animals seem to be the most sensitive organism tested.

Toxicities of zinc in nutrient solutions have been demonstrated for a number of plants. A variety of fresh water plants tested manifested harmful symptoms at concentrations of 10 mg/l. Zinc sulfate has also been found to be lethal to many plants and it could impair agricultural uses of the water.

Zinc is not destroyed when treated by POTW, but will either pass through to the POTW effluent or be retained in the POTW sludge. It can interfere with treatment processes in the POTW and can also limit the usefuleness of municipal sludge.

In slug doses, and particularly in the presence of copper, dissolved zinc can interfere with or seriously disrupt the operation of POTW biological processes by reducing overall removal efficiencies, largely as a result of the toxicity of the metal to biological organisms. However, zinc solids in the form of hydroxides or sulfides do not appear to interfere with biological treatment processes, on the basis of available data. Such solids accumulate in the sludge.

The influent concentrations of zinc to POTW facilities have been observed by the EPA to range from 0.017 to 3.91 mg/l, with a median concentration of 0.33 mg/l. Primary treatment is not efficient in removing zinc; however, the microbial floc of secondary treatment readily adsorbs zinc.

In a study of 258 POTW, the median pass-through values were 70 to 88 percent for primary plants, 50 to 60 percent for trickling filter and biological process plants, and 30-40 percent for activated process plants. POTW effluent concentrations of zinc ranged from 0.003 to 3.6 mg/l (mean = 0.330, standard deviation = 0.464).

The zinc which does not pass through the POTW is retained in the sludge. The presence of zinc in sludge may limit its use on cropland. Sewage sludge contains 72 to over 30,000 mg/kg of zinc, with 3,366 mg/kg as the mean value. These concentrations are significantly greater than those normally found in soil, which range from 0 to 195 mg/kg, with 94 mg/kg being a common level. Therefore, application of sewage sludge to soil will generally increase the concentration of zinc in the soil. Zinc can be toxic to plants, depending upon soil pH. Lettuce, tomatoes, turnips, mustard, kale, and beets are especially sensitive to zinc contamination.

Xylene (130). Xylene ($C_6H_4(CH_3)_2$) is a colorless flammable liquid with a density of 0.86 g/ml. The boiling point ranges from 137 to 140°C, and the flash point is 29°C. Xylene is practically insoluble in water, but it is miscible with alcohol, ether, and many other organic liquids. Xylene is commonly a mixture of three isomers, ortho, meta, and para-xylene, with m-xylene predominating. Xylene is manufactured from pseudocumene, or by catalytic isomerization of a hydrocarbon fraction.

Xylene is predominately used as a solvent, for the manufacture of dyes and other organics, and as a raw material for production of benzoic acid, phthalic anhydride and other acids and esters used, in the manufacture of polyester fibers.

Xylene has been shown to have a narcotic effect on humans exposed to high concentrations. The chronic toxicity of xylene has not been defined, however, it is less toxic than benzene.

Data on the behavior of xylene in POTW are not available. However, the methyl groups in xylene tend to transfer electrons to the benzene ring and make it more susceptible to biochemical oxidation. This observation in addition to the low water solubility of xylene, leads to the expectation that aeration processes will remove some xylene from the POTW.

Aluminum. Aluminum is a nonconventional pollutant. It is a silvery white metal, very abundant in the earths crust (8.1%), but never found free in nature. Its principal ore is bauxite. Alumina (Al_2O_3) is extracted from the bauxite and dissolved in molten cryolite. Aluminum is produced by electrolysis of this melt.

Aluminum is light, malleable, ductile, possesses high thermal and electrical conductivity, and is non-magnetic. It can be formed, machined or cast. Although aluminum is very reactive, it forms a protective oxide film on the surface which prevents corrosion under many conditions. In contact with other metals in presence of moisture the protective film is destroyed and voluminous white corrosion products form. Strong acids and strong alkali also break down the protective film. Aluminum is one of the principal basis metals used in the coil coating industry.

Aluminum is nontoxic and its salts are used as coagulants in water treatment. Although some aluminum salts are soluble, alkaline conditions cause precipitation of the aluminum as a hydroxide.

Aluminum is commonly used in cooking utensils. There are no reported adverse physiological effects on man from low concentrations of aluminum in drinking water.

Aluminum does not have any adverse effects on POTW operation at any concentrations normally encountered.

Ammonia. Ammonia (chemical formula NH_3) is a non-conventional pollutant. It is a colorless gas with a very pungent odor, detectable at concentrations of 20 ppm in air by the nose, and is very soluble in water (570 gm/l at 25°C). Ammonia is produced industrially in very large quantities (nearly 20 millions tons annually in the U.S.). It is converted to ammonium compounds or shipped in the liquid form (it liquifies at -33°C). Ammonia also results from natural processes. Bacterial action on nitrates or nitrites, as well as dead plant and animal tissue and animal wastes produces ammonia. Typical domestic wastewaters contain 12 to 50 mg/l ammonia.

The principal use of ammonia and its compounds is as fertilizer. High amounts are introduced into soils and the water runoff from agricultural land by this use. Smaller quantities of ammonia are used as a refrigerant. Aqueous ammonia (2 to 5 percent solution) is widely used as a household cleaner. Ammonium compounds find a variety of uses in various industries.

Ammonia is toxic to humans by inhalation of the gas or ingestion of aqueous solutions. The ionized form (NH_4^+) is less toxic than the un-ionized form. Ingestion of as little as one ounce of household ammonia has been reported as a fatal dose. Whether inhaled or ingested, ammonia acts distructively on mucous membrane with resulting loss of function. Aside from breaks in liquid ammonia refrigeration equipment, industrial hazard from ammonia exists where solutions of ammonium compounds may be accidently treated with a strong alkali, releasing ammonia gas. As little as 150 ppm ammonia in air is reported to cause laryngeal spasm, and inhalation of 5000 ppm in air is considered sufficient to result in death.

Freshwater ambient water criteria for total ammonia are pH and temperature dependent; un-ionized ammonia criteria is 0.02 mg/l. The reported odor threshold for ammonia in water is 0.037 mg/l. Un-ionized ammonia is acutely or chronically toxic to many important freshwater and marine aquatic organisms at ambient water concentrations below 4.2 mg/l. Salmonoid fishes are especially sensitive to the toxic effects of un-ionized ammonia at concentrations as low as 0.025 mg/l during prolonged exposure. Because the proportion of un-ionized ammonia varies with environmental conditions and cannot be directly controlled in the ambient water, total ammonia is the pollutant which must be controlled.

The behavior of ammonia in POTW is well documented because it is a natural component of domestic wastewaters. Only very high concentrations of ammonia compounds could overload POTWs. One study has shown that concentrations of un-ionized ammonia greater than 90 mg/l reduce gasification in anaerobic digesters and concentrations of 140 mg/l stop digestion competely. Corrosion of copper piping and excessive consumption of chlorine also result from high ammonia concentrations. Interference with aerobic nitrification processes can occur when large concentrations of ammonia suppress dissolved oxygen. Nitrites are then produced instead of nitrates. Elevated nitrite concentrations in drinking water are known to cause infant methemoglobinemia.

Fluoride. Fluoride ion (F^-) is a nonconventional pollutant. Fluorine is an extremely reactive, pale yellow, gas which is never found free in nature. Compounds of fluorine - fluorides - are found widely distributed in nature. The principal minerals containing fluorine are fluorspar (CaF_2) and cryolite (Na_3AlF_6). Although fluorine is produced commercially in small quantities by electrolysis of potassium bifluoride in anhydrous hydrogen fluoride, the elemental form bears little relation to the combined ion. Total production of fluoride chemicals in the U.S. is difficult to estimate because of the varied uses. Large volume usage compounds are: Calcium fluoride (est. 1,500,000 tons in U.S.) and sodium fluoroaluminate (est. 100,000 tons in U.S.). Some fluoride compounds and their uses are: sodium fluoroaluminate - aluminum production; calcium fluoride - steelmaking, hydrofluoric acid production, enamel, iron foundry; boron trifluoride - organic synthesis; antimony pentafluoride - fluorocarbon production; fluoboric acid and fluoborates - electroplating; perchloryl fluoride (ClO_3F) - rocket fuel oxidizer; hydrogen fluoride - organic fluoride manufacture, pickling acid in stainless steelmaking, manufacture of alumium fluoride; sulfur hexafluoride - insulator in high voltage transformers; polytetrafluoroethylene - inert plastic. Sodium fluoride is used at a concentration of about 1 ppm in many public drinking water supplies to prevent tooth decay in children.

The toxic effects of fluoride on humans include severe gastroenteritis, vomiting diarrhea, spasms, weakness, thirst, failing pulse and delayed blood coagulation. Most observations of toxic effects are made on individuals who intentionally or accidentally ingest sodium fluoride intended for use as rat poison or insecticide. Lethal doses for adults are estimated to be as low as 2.5 g. At 1.5 ppm in drinking water, mottling of tooth enamel is reported, and 14 ppm, consumed over a period of years, may lead to deposition of calcium fluoride in bone and tendons.

Very few data are available on the behavior of fluoride in POTW. Under usual operating conditions in POTW, fluorides pass through into the effluent. Very little of the fluoride entering conventional primary and secondary treatment processes is removed. In one study of POTW influents conducted by the U.S. EPA, nine POTW reported concentrations of fluoride ranging from 0.7 mg/l to 1.2 mg/l, which is the range of concentrations used for fluoridated drinking water.

Iron. Iron is a nonconventional polluant. It is an abundant metal found at many places in the earth's crust. The most common iron ore is hematite (Fe_2O_3) from which iron is obtained by reduction with carbon. Other forms of commercial ores are magnetite (Fe_3O_4) and taconite (FeSiO). Pure iron is not often found in commercial use, but it is usually alloyed with other metals and minerals. The most common of these is carbon.

Iron is the basic element in the production of steel. Iron with carbon is used for casting of major parts of machines and it can be machined, cast, formed, and welded. Ferrous iron is used in paints, while powdered iron can be sintered and used in powder metallurgy. Iron compounds are also used to precipitate other metals and undesirable minerals from industrial wastewater streams.

Corrosion products of iron in water cause staining of porcelain fixtures, and ferric iron combines with tannin to produce a dark violet color. The presence of excessive iron in water discourages cows from drinking and thus reduces milk production. High concentrations of ferric and ferrous ions in water kill most fish introduced to the solution within a few hours. The killing action is attributed to coatings of iron hydroxide precipitates on the gills.

Iron oxidizing bacteria are dependent on iron in water for growth. These bacteria form slimes that can affect the aesthetic values of bodies of water and cause stoppage of flows in pipes.

Iron is an essential nutrient and micro-nutrient for all forms of growth. Drinking water standards in the U.S. set a limit of 0.3 mg/l of iron in domestic water supplies based on aesthetic and organoleptic properties of iron in water.

High concentrations of iron do not pass through a POTW into the effluent. In some POTW iron salts are added to coagulate precipitates and suspended sediments into a sludge. In an EPA study of POTW the concentration of iron in the effluent of 22 biological POTW meeting secondary treatment performance levels ranged from 0.048 to 0.569 mg/l with a median value of 0.25 mg/l. This represented removals of 76 to 97 percent with a median of 87 percent removal.

Iron in sewage sludge spread on land used for agricultural purposes is not expected to have a detrimental effect on crops grown on the land.

Phenols(Total). "Total Phenols" is a nonconventional pollutant parameter. Total phenols is the result of analysis using the 4-AAP (4-aminoantipyrene) method. This analytical procedure measures the color development of reaction products between 4-AAP and some phenols. The results are reported as phenol. Thus "total phenol" is not total phenols because many phenols (notably nitrophenols) do not react. Also, since each reacting phenol contributes to the color development to a different degree, and each phenol has a molecular weight different from others and from phenol itself, analyses of several mixtures containing the same total concentration in mg/l of several phenols will give different numbers depending on the proportions in the particular mixture.

Despite these limitations of the analytical method, total phenols is a useful analysis when the mix of phenols is relatively constant and an inexpensive monitoring method is desired. In any given plant or even in an industry subcategory, monitoring of "total phenols" provides an indication of the concentration of this group of priority pollutants as well as those phenols not selected as priority pollutants. A further advantage is that the method is widely used in water quality determinations.

In an EPA survey of 103 POTW the concentration of "total phenols" ranged grom 0.0001 mg/l to 0.176 mg/l in the influent, with a median concentration of 0.016 mg/l. Analysis of effluents from 22 of these same POTW which had biological treatment meeting secondary treatment performance levels showed "total phenols" concentrations ranging from 0 mg/l to 0.203 mg/l with a median of 0.007. Removals were 64 to 100 percent with a median of 78 percent.

It must be recognized, however, that six of the eleven priority pollutant phenols could be present in high concentrations and not be detected. Conversely, it is possible, but not probable, to have a high "total phenol" concentration without any phenol itself or any of the ten other priority pollutant phenols present. A characterization of the phenol mixture to be monitored to establish constancy of composition will allow "total phenols" to be used with confidence.

Oil and Grease. Oil and grease are taken together as one pollutant parameter. This is a conventional polluant and some of its components are:

1. Light Hydrocarbons - These include light fuels such as gasoline, kerosene, and jet fuel, and miscellaneous sol- vents used for industrial processing, degreasing, or cleaning purposes. The presence of these light hydro- carbons may make the removal of other heavier oil wastes more difficult.

2. Heavy Hydrocarbons, Fuels, and Tars - These include the crude oils, diesel oils, #6 fuel oil, residual oils, slop oils, and in some cases, asphalt and road tar.

3. Lubricants and Cutting Fluids - These generally fall in- to two classes: nonemulsifiable oils such as lubrica- ting oils and greases and emulsifiable oils such as water soluble oils, rolling oils, cutting oils, and draw- ing compounds. Emulsifiable oils may contain fat soap or various other additives.

4. Vegetable and Animal Fats and Oils - These originate primarily from processing of foods and natural products.

These compounds can settle or float and may exist as solids or liquids depending upon factors such as method of use, production process, and temperature of wastewater.

Oil and grease even in small quantities cause troublesome taste and odor problems. Scum lines from these agents are produced on water treatment basin walls and other containers. Fish and water fowl are adversely affected by oils in their habitat. Oil emulsions may adhere to the gills of fish causing suffocation, and the flesh of fish is tainted when microorganisms that were exposed to waste oil are eaten. Deposition of oil in the bottom sediments of water can serve to inhibit normal benthic growth. Oil and grease exhibit an oxygen demand.

Many of the organic priority pollutants will be found distributed between the oily phase and the aqueous phase in industrial wastewaters. The presence of phenols, PCBs, PAHs, and almost any other organic pollutant in the oil and grease make characterization of this parameter almost impossible. However, all of these other organics add to the objectionable nature of the oil and grease.

Levels of oil and grease which are toxic to aquatic organisms vary greatly, depending on the type and the species susceptibility. However, it has been reported that crude oil in concentrations as low as 0.3 mg/l is extremely toxic to fresh-water fish. It has been recommended that public water supply sources be essentially free from oil and grease.

Oil and grease in quantities of 100 l/sq km show up as a sheen on the surface of a body of water. The presence of oil slicks decreases the aesthetic value of a waterway.

Oil and grease is compatible with a POTW activated sludge process in limited quantity. However, slug loadings or high concentrations of oil and grease interfere with biological treatment processes. The oils coat surfaces and solid particles, preventing access of oxygen, and sealing in some microorganisms. Land spreading of POTW sludge containing oil and grease uncontaminated by toxic pollutants is not expected to affect crops grown on the treated land, or animals eating those crops.

pH. Although not a specific pollutant, pH is related to the acidity or alkalinity of a wastewater stream. It is not, however, a measure of either. The term pH is used to describe the hydrogen ion concentration (or activity) present in a given solution. Values for pH range from 0 to 14, and these numbers are the negative logarithms of the hydrogen ion concentrations. A pH of 7 indicates neutrality. Solutions with a pH above 7 are alkaline, while those solutions with a pH below 7 are acidic. The relationship of pH and acidity and alkalinity is not necessarily linear or direct. Knowledge of the water pH is useful in determining necessary measures for corroison control, sanitation, and disinfection. Its value is also necessary in the treatment of industrial wastewaters to determine amounts of chemcials required to remove pollutants and to measure their effectiveness. Removal of pollutants, especially dissolved solids is affected by the pH of the wastewater.

Waters with a pH below 6.0 are corrosive to water works structures, distribution lines, and household plumbing fixtures and can thus add constituents to drinking water such as iron, copper, zinc, cadmium, and lead. The hydrogen ion concentration can affect the taste of the water and at a low pH, water tastes sour. The bactericidal effect of chlorine is weakened as the pH increases, and it is advantageous to keep the pH close to 7.0. This is significant for providng safe drinking water.

Extremes of pH or rapid pH changes can exert stress conditions or kill aquatic life outright. Even moderate changes from acceptable criteria limits of pH are deleterious to some species. The relative toxicity to aquatic life of many materials is increased by changes in the water pH. For example, metallocyanide complexes can increase a thousand-fold in toxicity with a drop of 1.5 pH units.

Because of the universal nature of pH and its effect on water quality and treatment, it is selected as a pollutant parameter for many industry categories. A neutral pH range (approximately 6-9) is generally desired because either extreme beyond this range has a deleterious effect on receiving waters or the pollutant nature of other wastewater constituents.

Pretreatment for regulation of pH is covered by the "General Pretreatment Regulations for Exisiting and New Sources of Pollution," 40 CFR 403.5. This section prohibits the discharge to a POTW of "pollutants which will cause corrosive structural damage to the POTW but in no case discharges with pH lower than 5.0 unless the works is specially designed to accommodate such discharges."

Sulfides. Sulfides are constituents of many industrial wastes such as those from tanners, paper mills, chemical plants, and gas works; but they are also generated in sewage and some natural waters by the anerobic decomposition of organic matter. When added to water, soluble sulfide salts such as Na_2S dissociate into sulfide ions which in turn react with the hydrogen ions in the water to form HS- or H_2S, the proportion of each depending upon the resulting pH value.

Due to the unpleasant taste and odor which exist when sulfides are present in water, it is unlikely that any person or animal would consume a harmful dose. The threshold level of taste and smell are reported to be 0.2 mg/l of sulfides in pump-mill wastes. For industrial uses, however, even small traces of sulfides are often detrimental.

The toxicity of sulfide solutions toward fish increases as the pH value is lowered, i.e., the H_2S or HS- appears to be the principle toxic agent. Experiments with trout substantiate this statement. However, inorganic sulfides have also proved fatal to trout at concentrations between 0.5 and 1.0 mg/l as sulfide, even in neutral and somewhat alkaline solutions.

Tin. Tin is a silver-white, lustrous and malleable metal with a density of 7.31 g/ml. The melting point of tin is 231.9°C while the boiling point is 2507°C.

Tin is used chiefly for tin-plating, soldering alloys and babbitt type metals.

Tin is not present in natural waters but it may occur in industrial wastes. Tin salts therefore, may reach surface waters or groundwater; but because many of the salts are insoluble in water, it is unlikely that much of the tin will remain in solution or suspension. No reports have been uncovered to indicate that tin can be detrimental in domestic water supplies.

Rats have tolerated 25 mg or more of sodium stannuous tartrate in the diet over a period of 4-12 months without ill effects. Similar tests with other animals had similar results - no ill effects. On the basis of these feeding experiments, it is unlikely that any concentration of tin that could occur in water would be detrimental to livestock.

It is apparent that trace concentrations of tin are beneficial to fish. However, higher levels have proved fatal to eels which were tested.

Total Suspended Solids(TSS). Suspended solids include both organic and inorganic materials. The inorganic compounds include sand, silt, and clay. The organic fraction includes such materials as grease, oil, tar, and animal and vegetable waste products. These solids may settle out rapidly, and bottom deposits are often a mixture of both organic and inorganic solids. Solids may be suspended in water for a time and then settle to the bed of the stream or lake. These solids discharged with man's wastes may be inert, slowly biodegradable materials, or rapidly decomposable substances. While in suspension, suspended solids increase the turbidity of the water, reduce light penetration, and impair the photosynthetic activity of aquatic plants.

Supended solids in water interfere with many industrial processes and cause foaming in boilers and incrustastions on equipment exposed to such water, especially as the temperature rises. They are undesirable in process water used in the manufacture of steel, in the textile industry, in laundries, in dyeing, and in cooling systems.

Solids in suspension are aesthetically displeasing. When they settle to form sludge deposits on the stream or lake bed, they are often damaging to the life in the water. Solids, when transformed to sludge deposit, may do a variety of damaging things, including blanketing the stream or lake bed and thereby destroying the living spaces for those benthic organisms that would otherwise occupy the habitat. When of an organic nature, solids use a portion or all of the dissolved oxygen available in the area. Organic materials also serve as a food source for sludgeworms and associated organisms.

Disregarding any toxic effect attributable to substances leached out by water, suspended solids may kill fish and shellfish by causing abrasive injuries and by clogging the gills and respiratory passages of various aquatic fauna. Indirectly, suspended solids are inimical to aquatic life because they screen out light, and they promote and maintain the development of noxious conditions through oxygen depletion. This results in the killing of fish and fish food organisms. Suspended solids also reduce the recreational value of the water.

Total suspended solids is a traditional pollutant which is compatible with a well-run POTW. This pollutant with the exception of those components which are described elsewhere in this section, e.g., heavy metal components, does not interfere with the operation of a POTW. However, since a considerable portion of the innocuous TSS may be inseparably bound to the constituents which do interfere with POTW operation, or produce unusable sludge, or subsequently dissolve to produce unacceptable POTW effluent, TSS may be considered a toxic waste hazard.

Regulated Pollutants

Most of the toxic pollutants (29) are found in the coke- making subcategory. In order to avoid costly analytical work three organic indicator pollutants are proposed for limitation.

The final list of pollutants proposed for limitation is found in Table V-3. This list consists of 21 pollutants; 14 toxic, 4 nontoxic nonconventional, and 3 conventional. Table V-4 lists the pollutants proposed for limitation by subcategory.

TABLE V-1

DEVELOPMENT OF REGULATED POLLUTANT LIST
IRON & STEEL INDUSTRY

No.	Pollutant	Not Detected	Environmentally Insignificant	Not Treatable(1)	Regulation Considered
001	Acenaphthene	-	-	X	-
002	Acrolein	X	-	-	-
003	Acrylonitrile	-	-	-	X
004	Benzene	-	-	-	X
005	Benzidine	X	-	-	-
006	Carbon tetrachloride	-	-	X	-
007	Chlorobenzene	X	-	-	-
008	1,2,4-trichlorobenzene	X	-	-	-
009	Hexachlorobenzene	-	-	-	X
010	1,2-dichloroethane	-	-	X	-
011	1,1,1-trichloroethane	-	-	-	X
012	Hexachlorethane	X	-	-	-
013	1,1-dichloroethane	-	-	X	-
014	1,1,2-trichloroethane	-	X	-	-
015	1,1,2,2-tetrachloroethane	-	-	X	-
016	Chloroethane	X	-	-	-
017	bis(chloromethyl)ether	X	-	-	-
018	bis(2-chloroethyl)ether	X	-	-	-
019	2-chloroethyl vinyl ether	X	-	-	-
020	2-chloronaphthalene	-	-	X	-
021	2,4,6-trichlorophenol	-	-	-	X
022	Parachlorometacresol	-	-	-	X
023	Chloroform	-	-	-	X
024	2-chlorophenol	-	-	-	X
025	1,2-dichlorobenzene	-	-	X	-
026	1,3-dichlorobenzene	X	-	-	-
027	1,4-dichlorobenzene	-	-	X	-
028	3,3'-dichlorobenzidine	X	-	-	-
029	1,1-dichloroethylene	-	X	-	-
030	1,2-trans-dichloroethylene	-	-	X	-
031	2,4-dichlorophenol	-	-	X	-
032	1,2-dichloropropane	X	-	-	-
033	1,2-dichloropropylene	X	-	-	-
034	2,4-dimethyl phenol	-	-	-	X
035	2,4-dinitrotoluene	-	-	-	X
036	2,6-dinitrotoluene	-	-	-	X
037	1,2-diphenylhydrazine	-	-	X	-
038	Ethylbenzene	-	-	-	X
039	Fluoranthene	-	-	-	X
040	4-chlorophenyl phenyl ether	X	-	-	-
041	4-bromophenyl phenyl ether	X	-	-	-
042	bis(2-chloroisopropyl) ether	X	-	-	-
043	bis(2-chloroethoxy) methane	X	-	-	-
044	Methylene chloride	-	-	X	-

TABLE V-1
DEVELOPMENT OF REGULATED POLLUTANT LIST
IRON & STEEL INDUSTRY
PAGE 2

No.	Pollutant	Not Detected	Environmentally Insignificant	Not Treatable[(1)]	Regulation Considered
045	Methyl chloride	X	-	-	-
046	Methyl bromide	X	-	-	-
047	Bromoform	X	-	-	-
048	Dichlorobromomethane	-	-	X	-
049	Trichlorofluoromethane	X	-	-	-
050	Dichlorodifluoromethane	X	-	-	-
051	Chlorodibromomethane	X	-	-	-
052	Hexachlorobutadiene	X	-	-	-
053	Hexachlorocyclopentadiene	X	-	-	-
054	Isophorone	-	-	-	X
055	Naphthalene	-	-	-	X
056	Nitrobenzene	-	-	X	-
057	2-nitrophenol	-	-	-	X
058	4-nitrophenol	-	-	X	-
059	2,4-dinitrophenol	-	-	X	-
060	4,6-dinitro-o-cresol	-	-	-	X
061	N-nitrosodimethylamine	X	-	-	-
062	N-nitrosodiphenylamine	X	-	-	-
063	N-nitrosodi-n-propylamine	X	-	-	-
064	Pentachlorophenol	-	-	-	X
065	Phenol	-	-	-	X
066	bis(2-ethylhexyl)phthalate	-	-	-	X
067	Butyl benzyl phthalate	-	-	-	X
068	Di-n-butyl phthalate	-	-	-	X
069	Di-n-octyl phthalate	-	-	-	X
070	Diethyl phthalate	-	-	-	X
071	Dimethyl phthalate	-	-	-	X
072	Benzo(a)anthracene	-	-	-	X
073	Benzo(a)pyrene	-	-	-	X
074	3,4-benzofluoranthene	-	X	-	-
075	Benzo(k)fluoranthene	-	X	-	-
076	Chrysene	-	-	-	X
077	Acenaphthylene	-	-	-	X
078	Anthracene	-	-	-	X
079	benzo(ghi)perylene	-	X	-	-
080	Fluorene	-	-	-	X
081	Phenathrene	-	-	-	X
082	Dibenzo(a,h)anthracene	-	X	-	-
083	Indeno(1,2,3,cd)pyrene	-	X	-	-
084	Pyrene	-	-	-	X
085	Tetrachloroethylene	-	-	-	X
086	Toluene	-	-	-	X
087	Trichlorethylene	-	-	X	-
088	Vinyl chloride	-	X	-	-
089	Aldrin	-	X	-	-

TABLE V-1
DEVELOPMENT OF REGULATED POLLUTANT LIST
IRON & STEEL INDUSTRY
PAGE 3

No.	Pollutant	Not Detected	Environmentally Insignificant	Not Treatable[1]	Regulation Considered
090	Dieldrin	-	X	-	-
091	Chlordane	-	X	-	-
092	4,4'-DDT	-	X	-	-
093	4,4'-DDE	-	X	-	-
094	4,4'-DDD	-	X	-	-
095	a-endosulfan-Alpha	-	X	-	-
096	b-endosulfan-Beta	-	X	-	-
097	Endosulfan sulfate	-	X	-	-
098	Endrin	-	X	-	-
099	Endrin aldehyde	-	X	-	-
100	Heptachlor	-	X	-	-
101	Heptachlor epoxide	-	X	-	-
102	a-BHC-Alpha	-	X	-	-
103	b-BHC-Beta	-	X	-	-
104	r-BHC-Gamma	-	X	-	-
105	g-BHC-Delta	-	X	-	-
106	PCB-1242	-	X	-	-
107	PCB-1254	-	X	-	-
108	PCB-1221	-	X	-	-
109	PCB-1232	-	X	-	-
110	PCB-1248	-	X	-	-
111	PCB-1260	-	X	-	-
112	PCB-1016	-	X	-	-
113	Toxaphene	-	X	-	-
114	Antimony	-	-	-	X
115	Arsenic	-	-	-	X
116	Asbestos	X	-	-	-
117	Beryllium	-	-	X	-
118	Cadmium	-	-	-	X
119	Chromium	-	-	-	X
120	Copper	-	-	-	X
121	Cyanide	-	-	-	X
122	Lead	-	-	-	X
123	Mercury	-	-	X	-
124	Nickel	-	-	-	X
125	Selenium	-	-	-	X
126	Silver	-	-	-	X
127	Thallium	-	-	-	X
128	Zinc	-	-	-	X
129	2,3,7,8-tetrachlordibenzo-p-dioxin	X	-	-	-
130	Xylene	-	-	-	X

TABLE V-1
DEVELOPMENT OF REGULATED POLLUTANT LIST
IRON & STEEL INDUSTRY
PAGE 4

No.	Pollutant	Not Detected	Environmentally Insignificant	Not Treatable(1)	Regulation Considered
	Aluminum	-	-	-	X
	Ammonia	-	-	-	X
	Dissolved Iron	-	-	-	X
	Fluoride	-	-	-	X
	Hexavalent Chromium	-	-	-	X
	Manganese	-	X	-	-
	Oil and Grease	-	-	-	X
	pH	-	-	-	X
	Phenolic Compounds	-	-	-	X
	Chlorine Residual	-	-	-	X
	Total Suspended Solids	-	-	-	X

X: Indicates heading which applies to pollutant.
-: Indicates heading which does not apply to pollutant.
(1) Concentration of pollutant found at levels below treatability. However, pollutant load could be reduced by recycle.

TABLE V-2

POLLUTANTS CONSIDERED FOR REGULATION BY SUBCATEGORY IRON & STEEL INDUSTRY

No.	Pollutant	Coke-making	Sintering	Iron-making	Steel-making	Vacuum Degassing	Continuous Casting	Hot Forming	Scale Removal	Pickling	Cold Forming	Alkaline Cleaning	Hot Coatings
003	Acrylonitrile	X	-	-	-	-	-	-	-	-	-	-	-
004	Benzene	X	-	-	X	-	-	-	-	X	-	-	-
009	Hexachlorobenzene	-	-	X	-	-	-	-	-	-	-	-	-
011	1,1,1-trichloroethane	-	-	-	-	-	-	-	-	-	X	-	-
021	2,4,6-trichlorophenol	X	-	-	-	-	-	-	-	-	-	-	-
022	Parachlorometa-cresol	X	-	-	-	-	-	-	-	-	-	-	-
023	Chloroform	X	-	-	X	-	-	-	X	X	X	-	X
024	2-chlorophenol	-	-	-	-	-	-	-	-	-	X	-	-
031	2,4-Dichlorophenol	-	-	X	-	-	-	-	-	-	-	-	-
034	2,4-dimethylphenol	X	-	X	-	-	-	-	-	-	X	-	-
035	2,4-dinitrotoluene	X	-	-	-	-	-	-	-	-	-	-	-
036	2,6-dinitrotoluene	X	-	-	-	-	-	-	-	-	-	X	-
038	Ethylbenzene	X	-	-	-	-	-	-	-	-	X	-	-
039	Fluoranthene	X	X	X	X	-	-	-	-	-	-	X	X
054	Isophorone	X	-	-	-	-	-	-	-	-	-	-	-
055	Naphthalene	X	-	-	-	-	-	-	-	-	-	-	-
057	2-nitrophenol	-	-	-	-	-	-	-	-	-	X	-	-
058	4-Nitrophenol	-	-	-	X	-	-	-	-	-	-	-	-
060	4,6-dinitro-o-cresol	X	-	-	-	-	-	-	-	-	X	-	-
064	Pentachlorophenol	X	-	-	X	-	-	-	-	-	-	-	-
065	Phenol	X	X	X	-	-	-	-	-	-	X	-	-
066-071	Phthalates, total	X	-	-	-	-	-	-	-	-	-	-	-
072	Benzo(a)anthracene	X	-	-	-	-	-	-	-	-	-	-	-
073	Benzo(a)pyrene	X	-	X	-	-	-	-	-	-	-	-	-
076	Chrysene	X	X	X	-	-	-	-	-	-	-	-	-
077	Acenaphthylene	X	-	-	-	-	-	-	-	-	-	-	-
078	Anthracene	-	-	-	-	-	-	-	-	-	X	-	-
080	Fluorene	X	-	-	-	-	-	-	-	-	-	-	-
084	Pyrene	X	X	X	X	-	-	-	-	-	-	X	-
085	Tetrachloroethylene	-	-	-	-	-	-	-	-	-	X	-	-
086	Toluene	X	-	-	-	-	-	-	-	-	-	-	-

TABLE V-2
POLLUTANTS CONSIDERED FOR REGULATION BY SUBCATEGORY
IRON & STEEL INDUSTRY
PAGE 2

No.	Pollutant	Coke-making	Sintering	Iron-making	Steel-making	Vacuum Degassing	Continuous Casting	Hot Forming	Scale Removal	Pickling	Cold Forming	Alkaline Cleaning	Hot Coatings
114	Antimony	X	-	X	X	-	-	-	X	X	X	X	-
115	Arsenic	X	-	X	X	-	-	-	X	X	X	-	-
118	Cadmium	-	X	X	X	-	-	-	X	X	X	-	X
119	Chromium	-	X	X	X	X	X	X	X	X	X	-	X
120	Copper	X	X	X	X	X	X	X	X	X	X	-	X
121	Cyanide	X	X	X	X	-	-	-	X	-	-	X	-
122	Lead	-	X	X	X	X	X	X	X	X	X	X	X
124	Nickel	-	X	X	X	X	-	X	X	X	X	-	X
125	Selenium	X	-	X	X	-	X	-	X	-	-	X	-
126	Silver	-	X	X	X	-	-	-	X	X	-	-	-
127	Thallium	-	-	X	X	-	-	-	X	-	-	-	-
128	Zinc	X	X	X	X	X	X	X	X	X	X	X	X
130	Xylene	X	-	-	-	-	-	-	-	-	X	-	-
	Aluminum	-	-	-	-	-	-	-	-	-	-	-	X
	Ammonia	X	-	X	-	-	-	-	-	-	-	-	-
	Dissolved Iron	-	-	-	-	-	-	-	X	X	X	X	X
	Fluoride	-	X	X	X	-	-	-	-	X	-	-	-
	Hexavalent Chromium	-	-	-	-	-	-	-	X	-	-	-	-
	Oil and Grease	X	X	-	-	-	X	X	-	X	X	X	X
	pH	X	X	X	X	X	X	X	X	X	X	X	X
	Phenolic Compounds	X	X	X	-	-	-	-	-	-	-	-	-
	TRC	-	X	X	-	-	-	-	-	-	-	-	-
	Total Suspended Solids	X	X	X	X	X	X	X	X	X	X	X	X

X: Selected for consideration in development of regulated pollutant list in this subcategory.
-: Not selected for consideration in development of regulated pollutant list in this subcategory.

TABLE V-3

REGULATED POLLUTANT LIST
IRON & STEEL INDUSTRY

004	Benzene
011	1,1,1-Trichloroethane
055	Naphthalene
057	2-nitrophenol
073	Benzo(a)pyrene
078	Anthracene
085	Tetrachloroethylene
118	Cadmium
119	Chromium
120	Copper
121	Cyanide
122	Lead
124	Nickel
128	Zinc

Ammonia
Fluoride
Oil & Grease
pH
Phenol (4AAP)
Chlorine Residual
Total Suspended Solids

TABLE V-4

REGULATED POLLUTANT LIST BY SUBCATEGORY
IRON & STEEL INDUSTRY

No.	Pollutant	Cokemaking	Sintering	Ironmaking	Basic Oxygen Furnace (Steelmaking)	Open Hearth Furnace (Steelmaking)	Electric Arc Furnace (Steelmaking)	Vacuum Degassing	Continuous Casting	Hot Forming
004	Benzene	X	-	-	-	-	-	-	-	-
011	1,1,1-Trichloroethane	-	-	-	-	-	-	-	-	-
055	Naphthalene	X	-	-	-	-	-	-	-	-
057	2-Nitrophenol	-	-	-	-	-	-	-	-	-
073	Benzo(a)pyrene	X	-	-	-	-	-	-	-	-
078	Anthracene	-	-	-	-	-	-	-	-	-
085	Tetrachloroethylene	-	-	-	-	-	-	-	-	-
118	Cadmium	-	-	-	-	-	-	-	-	-
119	Chromium	-	-	-	X	X	X	X	X	X
120	Copper	-	-	-	-	-	-	-	-	-
121	Cyanide	X	X	X	-	-	-	-	-	-
122	Lead	-	X	X	X	X	X	X	X	X
124	Nickel	-	-	-	-	-	-	-	-	-
128	Zinc	-	X	X	X	X	X	X	X	X
	Ammonia	X	X	X	-	-	-	-	-	-
	Fluoride	-	-	-	-	-	-	-	-	-
	Oil & Grease	X	X	X	-	-	-	-	X	X
	pH	X	X	X	X	X	X	X	X	X
	Phenol (4AAP)	X	X	X	-	-	-	-	-	-
	Chlorine (Residual)	-	X	X	-	-	-	-	-	-
	Total Suspended Solids	X	X	X	X	X	X	X	X	X

TABLE V-4
REGULATED POLLUTANT LIST BY SUBCATEGORY
IRON & STEEL INDUSTRY
PAGE 2

No.	Pollutant	Kolene (Scale Removal)	Hydride (Scale Removal)	Sulfuric Acid Pickling	Hydrochloric Acid Pickling	Combination Acid Pickling	Recirculation and Combination (Cold Rolling)	Direct Application (Cold Rolling)	Alkaline Cleaning	Hot Coating
004	Benzene	-	-	-	-	-	-	-	-	-
011	1,1,1-Trichloroethane	-	-	-	-	-	X	-	-	-
055	Naphthalene	-	-	-	-	-	-	-	-	-
057	2-nitrophenol	-	-	-	-	-	X	-	-	-
073	Benzo(a)pyrene	-	-	-	-	-	-	-	-	-
078	Anthracene	-	-	-	-	-	X	-	-	-
085	Tetrachloroethylene	-	-	-	-	-	X	-	-	-
118	Cadmium	-	-	-	-	-	-	-	-	X
119	Chromium	X	X	X	X	X	X	X	-	X
120	Copper	-	-	-	-	X	-	-	-	-
121	Cyanide	-	X	-	-	-	-	-	-	-
122	Lead	-	X	X	X	-	X	X	-	X
124	Nickel	-	-	-	-	X	-	-	-	-
128	Zinc	-	-	X	X	-	X	X	-	X
	Ammonia	-	-	-	-	-	-	-	-	-
	Fluoride	-	-	-	-	X	-	-	-	-
	Oil & Grease	-	-	X	X	X	X	X	-	X
	pH	X	X	X	X	X	X	X	X	X
	Phenol (4AAP)	-	-	-	-	-	-	-	-	-
	Chlorine Residual	-	-	-	-	-	-	-	-	-
	Total Suspended Solids	X	X	X	X	X	X	X	X	X

X: Selected for regulation in this subcategory.
-: Not selected for regulation in this subcategory.

VOLUME I

SECTION VI

CONTROL AND TREATMENT TECHNOLOGY

A. Introduction

This section describes in-plant and end-of-pipe wastewater treatment technologies currently in use or available for use in the steel industry. The technology descriptions are grouped as follows: recycle; solids removal; oil removal; metals removal; organic pollutant removal; advanced technologies; and zero discharge technologies. The application and performance; advantages and limitations; reliability; maintainability; and demonstration status of each technology are presented. The treatment processes include both technologies presently demonstrated within the steel industry, and those demonstrated in other industries with similar wastewaters.

B. End of Pipe Treatment

Recycle Systems

Recycle is both an in-plant and end of pipe treatment operation to reduce the volume of wastewater discharged. In recycle systems, a percentage of the process wastewater is returned for reuse. Wastewater reuse reduces the discharge flow by reducing both the amount of water supplied to and the pollutant load discharged from the process.

Application and Performance

Recycle systems are included in the model technologies in eight of the twelve steel industry subcategories. The Agency estimates that the use of these recycle systems can result in a 53% reduction in process water discharges at the BPT level and a 95% reduction at the BAT level. To achieve these reductions, high degrees of recycle demonstrated in the industry have been included in model treatment systems as shown below:

Subcategory	Proposed BAT Recycle Rate (%)
Cokemaking (Barometric Condenser)	95
Sintering	95
Ironmaking	98
Steelmaking	94-100
Vacuum Degassing	98
Continuous Casting	99
Hot Forming	96
Acid Pickling (fume scrubber)	95-98

At high recycle rates, two problems can be encountered. First, if the wastewater is contaminated, a build-up of dissolved solids in the recycled water can cause plugging and corrosion. This difficulty can be avoided by providing sufficient treatment of the wastewater prior to recycle, by adding chemicals that inhibit scaling or corrosion, and by having sufficient blowdown to further control the build-up of other pollutants (i.e. dissolved solids) in the system. The second problem that can occur is excessive heat build-up in the recycled water. If the temperature of the water to be recycled is too high for its intended purpose, it must be cooled prior to recycle. The most common method of reducing the heat load of recycled water in the steel industry is with mechanical draft cooling towers. Mechanical draft evaporative cooling systems are capable of handling the wide range of operating conditions encountered in the steel industry. Cooling towers are included in the model treatment systems in four of the eight subcategories where recycle systems are considered.

Advantages and Limitations

As discussed above, recycle systems can achieve significant pollutant load reductions at relatively low cost. The system is controlled by simple instrumentation and relatively little operator attention is required.

The only potential limitation on the use of recycle systems is plugging and scaling. However, based upon the industry's response to basic and detailed questionnaires, the Agency believes that with proper attention and maintenance, plugging and scaling should not present a significant problem at the recycle rates proposed.

Operational Factors

1. Reliability

   The reliability of recycle systems is high, although proper monitoring and control are required for high rate systems. Chemical aids are often used in the recycle loops to maintain optimum operating conditions.

2. Maintainability

Most recycle systems include only simple pump stations and piping. These components require very little attention aside from routine maintenance.

Demonstration Status

Recycle systems are well demonstrated in the steel industry as well as numerous other industral applications. Full scale recycle systems have been in existence in the steel industry for many years. The recycle rates used to develop effluent limitations and standards for each subcategory have been demonstrated on a full scale basis in the industry.

Solids Removal

Many types of solids removal devices are in use in the steel industry including clarifiers, thickeners, inclined plate separators, settling lagoons, and filtration (mixed or single media; pressure or gravity). To simplify the discussion of solids removal only three broad categories are covered: (1) settling lagoons, (2) clarification which includes clarifiers, thickeners, and inclined plate separators and (3) filtration.

1. Settling Lagoon (or Basin)

Settling (sedimentation) is a process which removes solid particles from a liquid matrix by gravitational force. The operation reduces the velocity of the wastewater stream in a large volume tank or lagoon so that gravitational settling can occur. Because of the large wastewater volumes involved in the steel industry, lagoons are often large, on the order of 0.1 to 10 acres of surface area with a standard working depth of 7.5 feet. However, a survey of the industry has found lagoons up to 400 acres.

Long retention times are generally required for sedimentation. Accumulated sludge is removed either periodically or continuously and either manually or mechanically. But because simple sedimentation may require an excessively large settling area, and because high retention times (days as compared with hours) are usually required to effectively treat the wastewater, the addition of settling aids such as alum or polymetric flocculants is often used.

Sedimentation is often preceeded by chemical precipitation and coagulation. Chemical precipitation converts dissolved pollutants to solid form, while coagulation enhances settling by gathering together suspended precipitates into larger, faster settling particles.

Application and Performance

Settling lagoons are used in all steel industry subcategories. Most are terminal treatment lagoons which serve as a final treatment step prior to discharge. Often these lagoons are a main component in central treatment systems and are used to settle out solids from several process waste streams.

A properly operated sedimentation system is capable of efficiently removing suspended solids (including metal hydroxides), and other impurities from wastewater. The performance of the lagoon depends on a variety of factors, including the density and particle size of the solids, the effective charge of the suspended particles, and the types of chemicals used in pretreatment, if any.

Advantages and Limitations

The major advantage of solids removal by settling is the simplicity of the process itself. The major problem with simple settling is the long retention time necessary to achieve complete settling, especially if the specific gravity of the suspended matter is close to that of water. In addition, some materials are not removed by simple sedimentation alone (i.e., dissolved solids).

Operational Factors

a. Reliability: Settling can be a highly reliable technology for removing suspended solids. Sufficient retention time and regular sludge removal are important factors affecting the reliability of all settling systems. The proper control of pH, chemical precipitation, and coagulation or flocculation are additional factors which affect settling efficiencies.

b. Maintainability: Little maintenance is required for lagoons other than periodic sludge removal.

Demonstration Status

Based upon the survey of the industry through questionnaires and sampling trips, the Agency estimates that there are over 140 settling lagoons in use at 39 steel plant sites. Hence their use in the steel industry is well demonstrated.

2. Clarifiers

Clarifiers are another type of sedimentation device widely used in the steel industry. The chief benefit of a clarifier over a lagoon is that a clarifier reduces the land area requirements and the detention time. Solids removal efficiencies are generally in the same range as for settling lagoon systems. Conventional clarifiers consist of a circular or rectangular tank with either a mechanical sludge collecting device or with a sloping funnel- shaped bottom designed for sludge collection. In advanced clarifier designs, inclined plates or, slanted tubes may be placed in the the clarifier tank to increase the effective settling area and thus increase the capacity of the clarifier. As with settling lagoons, chemical aids are often added prior to clarification to enhance solids removal.

Application and Performance

The application of clarification is very similar to that described above for settling lagoons. Clarifiers are used in most subcategories to remove solids and suspended inorganic pollutants. Performance is also very similar to well operated lagoons as shown by the data presented in Appendix A.

The Agency statistically analyzed long-term data for several clarification systems. The Agency calculated the mean, standard deviation and other common statistical values, as well as the monthly average and daily maximum performance standards. A monthly average concentration was calculated based upon a 95 percentile while the daily maximum concentration was calculated with a 99 percentile. The methods used to determine these values are explained in Appendix A.

Based upon the data presented above, and other data presented in the subcategory reports, the Agency concluded that a 30-day average of 30 mg/l TSS and a 24 hour maximum of 60 mg/l TSS are attainable with clarification technology.

Advantages and Limitations

Clarification is more effective for removing suspended matter than simple settling systems. However, the cost of installing and maintaining a clarifier is greater than the costs associated with simple settling.

Inclined plate and slant tube settlers have removal efficiencies similar to conventional clarifiers, but have a greater capacity per unit area. The installed costs for these advanced clarifier systems are claimed to be one half the cost of conventional systems of similar capacity.

Operational Factors

a. Reliability: Similar to lagoon systems with proper control and maintenance. Clarifiers can achieve consistently low concentrations of solids and other pollutants in the wastewater.

Those advanced clarifiers using slanted tubes or inclined plates may require prescreening of the wastewater in order to eliminate any materials which could potentially clog the system.

b. Maintainability: The systems used for chemical pretreatment and sludge dragout must be maintained on a regular basis. Routine maintenance of mechanical parts is also necessary.

Demonstration Status

Clarifiers are used extensively in all subcategories of the steel industry. While the design may change slightly depending on the wastewaters being treated (i.e., steelmaking vs. pickling), all systems operate in a similar manner.

3. Filtration

Filtration is another common method used in the steel industry to remove solids (including particulate metals) and oils. Numerous types of filters and filter media are used in the steel industry and all work by similar mechanisms. Filters may be pressure or gravity type; single, dual, or mixed media; and the media can be sand, diatomaceous earth, walnut shells or some other material.

A filter may use a single media such as sand. However, by using dual or mixed (multiple) media, higher flow rates and efficiencies can be achieved. The dual media filter usually consists of a fine bed of sand under a coarser bed of another media. The coarse media removes most of the influent solids, while the fine sand performs final polishing.

In the steel industry, several considerations are important when filter systems are being designed. While either pressure or gravity systems may be used, the pressure systems are the most common and provide several advantages. A higher working pressure can be used with a pressure system and backwash storage and pumping facilities can be eliminated.

For typical steel industry applications, filter rates are in the range of 6 gpm per square foot to perhaps 18 gpm per square foot. At the higher rates, the efficiency of suspended solids removal is dependent upon the filtration rate, and the particle size. A knowledge of particle density, size distribution, and chemical composition is useful when selecting a filter design rate.

Filter media must be selected in conjunction with the filter design rate. The size and depth of the media is a primary consideration and other important factors are the chemical composition, sphericity, and hardness of the media chosen. The presence of relatively large amounts of oil in the wastewater to be filtered also affects the selection of the appropriate media.

During the filtration process, solids and oils accumulate in the bed and reduce the ability of the wastewater to flow through the media properly. To alleviate this problem, most filters go through a periodic cleaning cycle called backwashing. The method of backwashing and the design of backwash systems is an integral part of any deep-bed filtration system. Solids penetrate deeply into the bed and must be adequately removed during the backwashing cycle or problems may develop within the filtration system. Occasionally auxiliary means are employed to aid filter cleaning. Water jets used just below the surface of the expanded bed will aid solids and oil removals. Also, air can be used to augment the cleaning action of the backwash water to "scour" the bed free of solids and oils.

Filter system operation may be manual or automatic. The filter backwash cycle may be on a timed basis, a pressure drop basis with a terminal value which triggers backwash, or a solids carryover basis from turbidity monitoring of the outlet stream. Each of these methods is well demonstrated.

Application and Performance

In wastewater treatment plants, filters are often employed for final treatment following clarification, sedimentation or other similar operations. Filtration thus has potential application in nearly all industrial plants. Chemical additives which enhance the upstream treatment equipment may or may not be compatible with or enhance the filtration process. Normal operating flow rates for various types of filters are as follows:

Slow Sand	2.04-5.30 l/sq m-hr
Rapid Sand	40.74-51.48 l/sq m-hr
High Rate Mixed Media	81.48-122.22 l/sq m-hr

Suspended solids are commonly removed from wastewater streams by filtering through a deep 0.3-0.9 m (1-3 feet) granular filter bed. The porous media bed can be designed to remove practically all suspended particles. Even colloidal suspensions (roughly 1 to 100 microns) are adsorbed on the surface of the media grains as they pass in close proximity in the narrow bed passages.

Data gathered from short-term sampling visits show that filter plants in all subcategories readily produce effluents with less than 10 mg/l TSS (See Appendix A). However, the analysis of long-term data for ten filtration systems has shown that higher values are more appropriate for performance standards. Based upon the statistical analysis for long-term TSS data the Agency has determined that a 30-day average of 15 mg/l TSS and a 24 hour maximum of 40 mg/l TSS are attainable with filtration. Moreover, data for many steel industry subcategories demonstrate that these limits apply to all filtration systems regardless of the wastewater being treated.

Advantages and Limitations

The principal advantages of filtration are low initial and operating costs, modest land requirements, lower effluent solids concentration, and the reduction or elimination of chemical additions which add to the discharge stream. However, the filter may require pretreatment if the solids level is high (over 100 mg/l). In addition, operator training is necessary due to the controls and periodic backwashing involved.

Operational Factors

a. Reliability: The recent improvements in filter technology have significantly improved filtration reliability. Control systems, improved designs, and good operating procedures have made filtration a highly reliable method of water treatment.

b. Maintainability: Deep bed filters may be operated with either manual or automatic backwashing. In either case, they must be periodically inspected for media retention, partial plugging and leakage.

Demonstration Status

Filtration is one of the more common treatment methods used for steel industry wastewaters especially in the hot forming subcategory. This technology is used to treat a variety of wastewaters with similar results. Its ability to reduce the amount of solids, oils and metals in the wastewater is well demonstrated by both short and long-term data in the steel industry.

Oil Removal

Oils and greases are removed from process wastewaters by several methods in the steel industry including oil skimming, filtration, and air flotation. Also, ultrafiltration is used at one cold rolling plant to remove oils. Oils may also be incidentally removed through other treatment processes such as clarification. The source of these oils is usually lubricants and preservative coatings used in the various steelmaking and finishing operations.

As a general matter, the most effective first step in oil removal is to prevent it from mixing with the large volume wastewater flows by segregating the sumps in all cellars and by appropriate maintenance of the lubrication and greasing systems. If the segregation is accomplished, more efficient removals of the oils and greases from the wastewater can be accomplished. The oil removal equipment used in the steel industry is described below.

1. Skimming

Pollutants with a specific gravity less than water will often float unassisted to the surface of the wastewater. Skimming is used to remove these floating wastes. Skimming normally takes place in a tank designed to allow the floating debris to rise and remain on the surface, while the liquid flows to an outlet located below the floating layer. Skimming devices are therefore suited to the removal of nonemulsified oils from raw wastewaters. Common skimming mechanisms include the rotating drum type, which picks up oil from the surface of the water as the drum rotates. A doctor blade scrapes oil from the drum and collects it in a trough for disposal or reuse. The water portion is allowed to flow under the rotating drum. Occasionally, an underflow baffle is installed after the drum; this has the advantage of retaining any floating oil which escapes the drum skimmer. The belt type skimmer is pulled vertically through the water, collecting oil which is then scraped off from the belt surface and is collected in a drum. Gravity separators, such as the API type, use overflow and underflow baffles to skim a layer of floating oil from the surface of the wastewater. An overflow-underflow baffle allows a small amount of wastewater (the oil portion) to flow over into a trough for disposition or reuse while most of the water flows underneath the baffle. This is followed by an overflow baffle, which is set at a height relative to the first baffle such that only the oil bearing portion will flow over the first baffle during normal plant operation. A diffusion device, such as a vertical slot baffle, aids in creating a uniform flow through the system and increasing oil removal efficiency.

Application and Performance

Skimming may be used on any wastewater containing pollutants which float to the surface. It is commonly used to remove free oil, grease, and soaps. Skimming is often used in conjunction with air flotation or clarification in order to increase its effectiveness.

The removal efficiency of a skimmer is partly a function of the retention time of the water in the tank. Larger, more buoyant particles require less retention time than smaller particles. Thus, the efficiency also depends on the composition of the wastewater. The retention time required to allow phase separation and subsequent skimming varies from 1 to 15 minutes, depending on the wastewater characteristics.

API or other gravity-type separators tend to be more suitable for use where the amount of surface oil flowing through the system is fairly high and consistent. Drum and belt type skimmers are suitable where surges of floating oil are not a problem. Using an API separator system in conjunction with a drum type skimmer could be a very effective method of removing floating contaminants from nonemulsified oily waste streams. Data for various oil skimming operations are presented in Appendix A.

Advantages and Limitations

Skimming as pretreatment is effective in removing naturally floating waste material. It also improves the performance of subsequent downstream treatments.

Many pollutants, particularly dispersed or emulsified oil, will not float "naturally" but require additional treatment. Therefore, skimming alone may not remove all the pollutants capable of being removed by air flotation or other more sophisticated technologies.

Operational Factors

a. Reliability: Because of its simplicity, skimming is a very reliable technique. During cold weather, heating is usually required for the belt-type skimmers.

b. Maintainability: The skimming mechanism requires periodic lubrication, adjustment, and replacement of worn parts.

Demonstration Status

Skimming is a common method used to remove floating oil in many industrial categories, including the steel industry. Skimming is used widely in the hot forming, continuous casting, and cold forming subcategories.

2. Filtration

As explained above, filtration is also used to remove oils and greases from steel industry wastewaters. The mechanism for removing oils is very similar to the solids removal mechanism. The oils and grease, either floating or emulsified types, are directed into the filter where they are adsorbed on the filter media. Significant oil reductions can be achieved with filtration, and problems with the oils are not experienced unless high concentrations of oils are allowed to reach the filter bed. When this occurs the bed can be "blinded" and must be backwashed immediately. If too much oil is in the filter wastewater, frequent backwashing is necessary which makes the use of the technology unworkable. Therefore, proper pretreatment is essential for the proper operations of filtration equipment.

Application and Performance

The discussion presented above for filtration systems applies equally well here. The filter will reduce oil from moderate levels down to extremely low levels. Analysis of long-term data for eight filtration systems shows that an oil and grease limit as low as 3.5 mg/l can be readily attained on a 30-day average basis and 10 mg/l oil and grease on a daily maximum basis. However, because of problems with obtaining consistent analytical results in the range of 5 mg/l, EPA has decided to propose only a maximum effluent limitation based upon a daily maximum concentration of 10 mg/l.

Operational Factors and Demonstrated Status

See prior discussion on filtration.

3. Flotation

Flotation is a process which causes particles such as metal hydroxides or oil to float to the surface of a tank where they are concentrated and removed. Gas bubbles are released in the wastewater and attach to the solid particles, which increase their buoyancy and causes them to float. In principle, this process is the opposite of sedimentation.

Flotation is used primarily in the treatment of wastewaters that carry heavy loads of finely divided suspended solids or oil. Solids having a specific gravity only slightly greater than 1.0, which require abnormally long sedimentation times, may be removed in much less time by flotation.

This process may be performed in several ways: foam, dispersed air, dissolved air, gravity, and vacuum flotation are the most commonly used techniques. Chemical additives are often used to enhance the performance of the flotation process. For example, cold rolling operations often use acid and chemical aids to break emulsions used in the rolling solutions prior to flotation. This process greatly enhances the efficiency of flotation.

The principal difference between types of flotation techniques is the method of generating the minute gas bubbles (usually air) in a suspension of water and small particles. The use of chemicals to improve the efficiency may be employed with any of the basic methods. The different flotation techniques and the method of bubble generation for each process are described below.

Froth Flotation: Froth flotation is based upon the differences in the physiochemical properties of various particles. Wetability and surface properties affect particle affinity to gas bubbles. In froth flotation, air is blown through the solution containing flotation reagents.

The particles with water repellent surfaces stick to air bubbles and are brought to the surface. A mineralized froth layer, with mineral particles attached to air bubbles, is formed. Particles of other minerals which are readily wetted by water do not stick to air bubbles and remain in suspension.

Dispersed Air Flotation: In dispersed air flotation, gas bubbles are generated by introducing the air by means of mechanical agitation with impellers or by forcing air through porous media. Dispersed air flotation is used mainly in the metallurgical industry.

Dissolved Air Flotation: In dissolved air flotation, bubbles are produced as a result of the release of air from a supersaturated solution under relatively high pressure. There are two types of contact between the gas bubbles and particles. The first involves the entrapment of rising gas bubbles in the flocculated particles as they increase in size. The bond between the bubble and particle is one of physical capture only. This is the predominant type of contact. The second type of contact is one of adhesion. Adhesion results from the intermolecular attraction exerted at the interface between the solid particle and gaseous bubble.

Vacuum Flotation: This process consists of saturating the wastewater with air either directly in an aeration tank, or by permitting air to enter the suction of a wastewater pump. A partial vacuum causes the dissolved air to come out of solution as minute bubbles. The bubbles attach to solid particles and form a scum blanket on the surface, which is normally removed by a skimming mechanism. Grit and other heavy solids which settle to the bottom are generally raked to a central sludge pump for removal. A typical vacuum flotation unit consists of a covered cylindrical tank in which a partial vacuum is maintained. The tank is equipped with scum and sludge removal mechanisms. The floating material is continuously swept to the tank periphery, automatically discharged into a scum trough, and removed from the unit by a pump also under partial vacuum.

Application and Performance

Flotation is commonly used in the cokemaking and cold forming subcategories of the steel industry. Several cokemaking plants use gas (hydrogen) flotation to control oil levels. Also, plants in the cold forming (cold rolling) subcategory use dissolved air flotation after emulsion breaking and prior to final settling. Data for two steel industry flotation units are presented below. Plant 684F represents data on coke wastes while plant 0060B represents treatment of cold rolling wastes.

Performance of Flotation Units

Plant	Oil & Grease (mg/l) In	Oil & Grease (mg/l) Out
0684F	83	45
0060B	41,140	98

Advantages and Limitations

Some of the advantages of the flotation process are the high levels of solids and oil separation which are achieved in many applications; the relatively low energy requirements; and, the capability to adjust air flow to meet the varying requirements of treating different types of wastewaters. The limitations of flotation are that it often requires addition of chemicals to enhance process performance, and it generates large quantities of solid waste.

Operational Factors

a. Reliability: The reliability of a flotation system is normally high and is governed by the sludge collector mechanism and by the motors and pumps used for aeration.

b. Maintainability: Routine maintenance is required on the pumps and motors. The sludge collector mechanism is subject to possible corrosion or breakage and may require periodic replacement.

Demonstration Status

Flotation is a fully developed process and is readily available for the treatment of industrial wastewaters.

4. Ultrafiltration

Ultrafiltration (UF) is a process which uses semipermeable polymeric membranes to separate emulsified or colloidal materials suspended in a liquid phase by pressurizing the liquid so that it permeates the membrane. The membrane of an ultrafilter forms a molecular screen which retains molecular particles based on their differences in size, shape, and chemical structure. The membrane permits passage of solvents and lower molecular weight molecules. At present, an ultrafilter is capable of removing materials with molecular weights in the range of 1,000 to 100,000 and particles of comparable or larger sizes.

In an ultrafiltration process, the wastewater is pumped through a tubular membrane unit. Water and some low molecular weight materials pass through the membrane under the applied pressure of 10 to 100 psig. Emulsified oil droplets and suspended particles are retained, concentrated, and removed continuously. In contrast to ordinary filtration, retained materials are washed off the membrane filter rather than held by it.

Application and Performance

Ultrafiltration has potential application in cold rolling plants for separating oils and residual solids from the process wastes. Because of its ability to remove emulsified oils with little or no pretreatment, it is ideally suited for many of the wastewaters generated by cold rolling mills. Also, some organic compounds of suitable molecular weight may be bound in the oily wastes which are removed. Hence, ultrafiltration could prove to be an effective means to achieve organic toxic pollutant removal for the cold rolling subdivision.

The following test data depict ultrafiltration performance at one plant which treats a combined waste from eleven cold rolling mills:

Ultrafiltration Performance

	Feed (mg/l)	Permeate (mg/l)
Oil (freon extractable)	82,210	140
TSS	2,220	199
Chromium	6.5	1.2
Copper	7.5	0.07
2-chlorophenol	35.5	ND
2-nitrophenol	70.0	0.02

When the concentration of pollutants in the wastewater is high (as above) the ultrafiltration unit may not adequately treat the wastewater alone. Additional clarification may be necessary prior to discharge.

Advantages and Limitations

Ultrafiltration is sometimes an attractive alternative to chemical treatment because of lower capital installation, and operating costs, very high oil and suspended solids removal and little required pretreatment. It places a positive barrier between pollutants and effluent which reduces the possibility of extensive pollutant discharge due to operator error or upset in settling and skimming systems. Another possible application is recovering alkaline values from alkaline cleaning solutions.

A limitation on the use of ultrafiltration for treating wastewaters is its narrow temperature range (18 to 30 degress C) for satisfactory operation. Membrane life is decreased with higher temperatures, but flux increases at elevated temperatures. Therefore, the surface area requirements are a function of temperature and become a tradeoff between initial costs and replacement costs for the membrane. In addition, ultrafiltration is not suitable for certain solutions. Strong oxidizing agents, solvents, and other organic compounds can dissolve the membrane. Fouling is sometimes a problem, although the high velocity of the wastewater normally creates enough turbulence to keep fouling at a minimum. Large solids particles are also sometimes capable of puncturing the membrane and must be removed by gravity settling or filtration prior to the ultrafiltration unit.

Operational Factors

a. Reliability: The reliability of an ultrafiltration system is dependent on the proper filtration, settling or other treatment of incoming waste streams to prevent damaging the membrane. Careful pilot studies should be done in each instance to determine necessary pretreatment steps and the exact membrane type to be used.

b. Maintainability: A limited amount of regular maintenance is required for the pumping system. In addition, membranes must be periodically changed. The maintenance associated with membrane plugging can be reduced by selecting a membrane with optimum physical characteristics and having a sufficient velocity of the wastewater. It is often necessary to occasionally pass a detergent solution through the system to remove an oil and grease film which accumulates on the membrane. With proper maintenance membrane life can be greater than twelve months.

Demonstration Status

The ultrafiltration process is well developed and commercially available for treatment of wastewater or recovery of certain high molecular weight liquid and solid contaminants. Over 100 units are presently in operation in the United States. Ultrafiltration is demonstrated in the steel industry in the cold forming subcategory.

Metals Removal

Steel industry wastewaters contain significant levels of toxic metal pollutants including chromium, lead, nickel, zinc and others. These pollutants are generally removed by chemical precipitation and sedimentation or filtration. Most can be effectively removed by precipitating metal hydroxides or carbonates through reactions with lime, sodium hydroxide, or sodium carbonate. Sodium sulfide, ferrous sulfide, or sodium bisulfide can also be used to precipitate metals as sulfide compounds with low solubilities.

Hexavalent chromium is generally present in galvanizing and kolene scale removal wastewater. Reduction of this pollutant to the trivalent form is required if precipitation as the hydroxide is to be achieved. Where sulfide precipitation is used, hexavalent chromium is reduced directly by the sulfide. Chromium reduction using sulfur dioxide or sodium bisulfite or by electrochemical techniques may be necessary, however, when hydroxides are precipitated.

Details on various metal removal technologies are presented below with typical treatability levels where data are available.

1. Chemical Precipitation

Dissolved toxic metal ions and certain anions may be chemically precipitated and removed by physical means such as sedimentation, filtration, or centrifugation. Several reagents are commonly used to effect this precipitation.

a. Alkaline compounds such as lime or sodium hydroxide may be used to precipitate many toxic metal ions as metal hydroxides. Lime also may precipitate phosphates as insoluble calcium phosphate and fluorides as calcium fluoride.

b. Both soluble sulfides such as hydrogen sulfide or sodium sulfide and insoluble sulfides such as ferrous sulfide may be used to precipitate many heavy metal ions as insoluble metal sulfides.

c. Carbonate precipitates may be used to remove metals either by direct precipitation using a carbonate reagent such as calcium carbonate or by converting hydroxides into carbonates using carbon dioxide.

These treatment chemicals may be added to a flash mixer or rapid mix tank, a presettling tank, or directly to a clarifier or other settling device. Because metal hydroxides tend to be colloidal in nature, coagulating agents may be added to facilitate settling. After the solids have been removed, a final pH adjustment may be required to reduce the high pH created by the alkaline treatment chemicals.

Chemical precipitation as a mechanism for removing metals from wastewater is a complex process made up of at least two steps: precipitation of the unwanted metals and removal of the precipitate. A small amount of metal will remain dissolved in the wastewater after complete precipitation. The amount of residual dissolved metal depends on the treatment chemicals used the solubility of the metal and co-precipitation effects. The effectiveness of this method of removing any specific metal depends on the fraction of the specific metal in the raw waste (and hence in the precipitate) and the effectiveness of suspended solids removal.

Application and Performance

Chemical precipitation is used in the steel industry for precipitation of dissolved metals including aluminum, antimony, arsenic, beryllium, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, tin, and zinc. The process is also applicable to any substance that can be transformed into an insoluble form such as fluorides, phosphates, soaps, sulfides, and others. Because it is simple and effective, chemical precipitation is extensively used for industrial waste treatment.

The performance of chemical precipitation depends on several variables; the most important are:

a. Maintenance of an alkaline pH throughout the precipitation reaction and subsequent settling.

b. Addition of a sufficient excess of treatment ions to drive the precipitation reaction to completion.

c. Addition of an adequate supply of sacrifical ions (such as iron or aluminum) to ensure precipitation and removal of specific target ions.

d. Effective removal of precipitated solids (see appropriate technologies discussed under "Solids Removal").

A discussion of the performance of some of the chemical precipitation technologies used in the steel industry is presented below.

Lime Precipitation - Sedimentation Performance

Lime is sometimes used in conjunction with sedimentation technology to precipitate metals. Numerous examples of this technology are demonstrated in the steel industry, mostly in the pickling subcategory. Data for two plants using this technology are shown below. Plant 0684F has a lime precipitation/sedimentation treatment system which treats steelmaking wastes. Plant 0396A has a pickling operation which includes lime precipitation and sedimentation technology.

Lime Precipitation - Sedimentation Performance

Pollutant	Concentration of Pollutants (mg/l)			
	Plant 684H		Plant 0396A	
	In	Out	In	Out
Cadmium	0.15	0.01	<0.02	<0.02
Chromium	0.63	0.009	0.44	0.07
Copper	1.17	0.03	0.99	0.17
Lead	22.30	0.08	2.40	0.57
Nickel	1.20	0.06	0.59	0.27
Zinc	30.00	0.33	3.20	0.24
TSS	1640	44	3050	43
pH	10.2	8.2-8.8	9.2	9.0

Lime Precipitation - Filtration Performance

A metals removal technology that is used in the steel industry similar to the lime/sedimentation system includes lime precipitation and filtration. These systems accomplish better solids and oil removal and also achieves slightly better control of the effluent concentration of the metallic elements. Data for two plants that employ lime precipitation/filtration technology are shown below. Pickling and galvanizing wastewaters are treated at plant 0612, while pickling, galvanizing and alkaline cleaning wastes are treated at plant 0112I. Pilot plant data for steelmaking wastewaters are presented in Table A-35 of Appendix A.

Lime Precipitation - Filtration Performance

Pollutant	Concentration of Pollutants (mg/l)			
	Plant 0612		Plant 0112I	
	In	Out	In	Out
Cadmium	0.02	0.02	0.01	0.01
Chromium	1.60	0.04	0.12	0.03
Copper	0.60	0.08	0.17	0.02
Lead	2.400	0.18	0.19	<0.10
Nickel	0.60	0.02	0.08	0.03
Zinc	285.00	0.12	18.00	0.13
TSS	350.00	11.00	199.00	1.00
pH	2.9-3.9	8.3-8.5	5.2-5.6	7.3-7.7

Sulfide Precipitation

Most metal sulfides are less soluble than hydroxides and the precipitates are frequently more dependably removed from water. Solubilities for selected metal hydroxides and sulfide precipitates are shown below:

Theoretical Solubilities of Hydroxides and Sulfides of Heavy Metals in Pure Water

Metal	Solubility of Metal, mg/l	
	As hydroxide	As sulfide
Cadmium(Cd^{+2})	2.3×10^{-5}	6.7×10^{-10}
Chromium (Cr^{+3})	8.4×10^{-5}	No precipitate
Copper (Cu^{+2})	2.2×10^{-2}	5.8×10^{-18}
Iron (Fe^{+2})	8.9×10^{-1}	3.4×10^{-5}
Lead (Pb^{+2})	2.1×10^{-0}	3.8×10^{-9}
Nickel (Ni^{+2})	6.9×10^{-3}	6.9×10^{-8}
Silver (Ag^{+2})	13.0×10^{-0}	7.4×10^{-12}
Tin (Sn^{+2})	1.1×10^{-4}	2.3×10^{-7}

Sulfide treatment has not been used in the steel industry on a full-scale basis. However, it has been used in other manufacturing process (e.g. electroplating) to remove metals from wastewaters with similar characteristics and pollutants to those of the steel industry.

In assessing whether this technology is transferable for use in steel industry, the Agency consulted numerous references; contacted sulfide precipitation equipment manufacturers, and gathered data from operating sulfide precipitation systems. The wastewaters treated by these sulfide precipitation systems were contaminated with many of the same toxic metals found in steel industry wastewaters and at similar concentrations. Accordingly, the Agency concluded that a transfer of the effectiveness of this technology is possible. However, as noted above there are no full scale systems currently in use in the steel industry.

Data for several sulfide/filtration systems are shown below.

Sulfide Precipitation/Filtration Performance

Concentration of Pollutants (mg/l)

Pollutant	Data Set #1		Data Set #2	
	In	Out	In	Out
Chromium	2.0	<0.1	2.4	<0.1
Iron	85.0	0.04	108	0.60
Nickel	0.6	0.10	0.68	<0.1
Zinc	27.0	<0.1	33.9	<0.1
TSS	320	4.0	-	-
pH	2.9	8.2	7.7	7.4

Another benefit of the sulfide precipitation technology is the ability to precipitate hexavalent chromium (Cr^{+6}) without prior reduction to the trivalent state as is required in the hydroxide process. When ferrous sulfide is used as the precipitant, iron and sulfide act as reducing agents for the hexavalent chromium according to the reaction:

$Cr_2O_3 + 2FeS + 7H_2O \rightarrow 2Fe(OH)_3 + 2Cr(OH)_3 + 2S + 2OH$

In this reaction, the sludge produced consists mainly of ferric hydroxides, chromic hydroxides and various metallic sulfides. Some excess hydroxyl ions are generated in this process, possibly requiring a downward pre-adjustment of pH.

Advantages and Limitations

Chemical precipitation is an effective technique for removing many pollutants from industrial wastewaters. It operates at ambient conditions and is well suited to automatic control. The use of chemical precipitation may be limited due to interference of chelating agents, chemical interferences from mixing wastewaters and treatment chemicals, and potentially hazardous situations involved with the storage and handling of those chemicals. Lime is usually added as a slurry when used in hydroxide precipitation. The slurry must be well mixed and the addition lines periodically checked to prevent fouling. In addition, hydroxide precipitation usually makes recovery of the precipitated metals difficult, because of the heterogeneous nature of most hydroxide sludges.

The major advantage of the sulfide precipitation process is that due to the low solubility of most metal sulfides, very high metal removal efficiencies can be achieved. Also, the sulfide process has the ability to remove chromates and dichromates without preliminary reduction of the chromium to the trivalent state. In addition, it will precipitate metals complexed with most complexing agents. However, care must be taken to maintain the pH of the solution at approximately 10 in order to prevent the generation of toxic sulfide gas during this process. For this reason ventilation of the treatment tanks may be a necessary precaution in most installations. The use of ferrous sulfide reduces or virtually eliminates the problem of hydrogen sulfide evolution. As with hydroxide precipitation, excess sulfide ion must be present to drive the precipitation reaction to completion. Since the sulfide ion itself is toxic, sulfide addition must be carefully controlled to maximize heavy metals precipitation with a minimum of excess sulfide to avoid the necessity of post treatment. Where excess sulfide is present, aeration of the effluent stream can aid in oxidizing residual sulfide to the less harmful sodium sulfate (Na_2SO_4). The cost of sulfide precipitants is high in comparison with hydroxide precipitants, and disposal of metallic sulfide sludges may pose problems. An essential element in effective sulfide precipitation is the removal of precipitated solids from the wastewater and proper disposal in an appropriate site. Sulfide precipitation will also generate a higher volume of sludge than hydroxide precipitation, resulting in higher disposal and dewatering costs. This is especially true when ferrous sulfide is used as the precipitant.

Sulfide precipitation may be used as a final tratement step after hydroxide precipitation-sedimentation. This treatment configuration may provide the better treatment effectiveness of sulfide precipitation while minimizing the variability caused by changes in raw waste and reducing the amount of sulfide precipitant required.

Operational Factors

a. Reliability: The reliability of alkaline chemical precipitation is high, although proper monitoring and control are necessary. Sulfide precipitation systems provide similar reliability.

b. Maintainability: The major maintenance needs involve periodic upkeep of monitoring equipment, automatic feeding equipment, mixing equipment, and other hardware. Removal of accumulated sludge is necessary for the efficient operation of precipitation-sedimentation systems.

Demonstration Status

Chemical precipitation of metal hydroxides is a classic waste treatment technology used in many industrial waste treatment systems. Chemical precipitation of metals in the carbonate form alone has been found to be feasible and, is used in commercial application to permit metals recovery and water reuse. Full scale commercial sulfide precipitation units are in operation at numerous installations, however, none are presently installed in the steel industry.

2. Filtration (for Metal Removal)

As discussed previously, filtration is a proven technology for the control of TSS and oil and grease. However, the filtration mechanism which reduces the concentration of the solids and oils also treats the metallic elements present. To determine the treatability levels for metals using filtration the Agency compiled all available data on these systems. Data on seventeen filtration systems were averaged to develop the treated effluent concentrations. The average treated effluent concentrations and the proposed monthly average concentration for five toxic metals are shown below:

Metal Removal with Filtration Systems

Pollutant	Monthly Average Concentration (mg/l)	Daily Maximum Concentration (mg/l)
Chromium	0.04	0.12
Copper	0.04	0.12
Lead	0.08	0.24
Nickel	0.05	0.16
Zinc	0.08	0.24

For purposes of developing effluent limitations, the Agency is using monthly average concentrations of 0.10 mg/l and daily maximum concentrations of 0.30 mg/l for each toxic metal. Reference is made to Appendix A for development of toxic metals effluent concentrations.

Advantages and Limitations

See prior discussion on filtration systems.

Operational Factors and Demonstration Status

See prior discussion on filtration systems.

Organic Removal

Thirty-three organic toxic pollutants were detected in steel industry wastewaters above treatability levels. Because some of these pollutants were present in significant levels, treatment was considered in several steel industry categories for toxic organics. Basically two demonstrated technologies were considered: carbon adsorption and biological treatment (activated sludge). These technologies are discussed separately below.

1. Carbon Adsorption

The use of activated carbon for removal of dissolved organics from water and wastewater has been demonstrated and is one of the most efficient organic removal processes available. Activated carbon has also been shown to be an effective adsorbent for many toxic metals, including mercury. This process is reversible, thus allowing activated carbon to be regenerated and reused by the application of heat and steam or solvent. Regeneration of carbon which has adsorbed significant metals, however, may be difficult.

The term activated carbon applies to any amorphous form of carbon that has been specially treated to give high adsorption capacities. Typical raw materials include coal, wood, coconut shells, petroleum base residues and char from sewage sludge pyrolysis. A carefully controlled process of dehydration, carbonization, and oxidation yields a product which is called activated carbon. This material has a high capacity for adsorption due primarily to the large surface area available for adsorption (500- 1500 square meters/gram) which result from a large number of internal pores. Pore sizes generally range in radius from 10-100 angstroms.

Activated carbon removes contaminants from water by the process of adsorption (the attraction and accumulation of one substance on the surface of another). Activated carbon preferentially adsorbs organic compounds and, because of this selectivity, is particularly effective in removing organic compounds from wastewaters.

Carbon adsorption requires pretreatment (usually filtration) to remove excess suspended solids, oils, and greases. Suspended solids in the influent should be less than 50 mg/l to minimize backwash requirements. A downflow carbon bed can handle much higher levels (up to 2000 mg/l), but frequent backwashing is required. Backwashing more than two or three times a day is not desirable. Oil and grease should be less than about 15 mg/l. A high level of dissolved inorganic material in the influent may cause problems with thermal carbon reactivation (i.e., scaling and loss of activity) unless appropriate preventive steps are taken. Such steps might include pH control, softening, or the use of an acid wash on the carbon prior to reactivation.

Activated carbon is available in both powdered and granular form. Powdered carbon is less expensive per unit weight and may have slightly higher adsorption capacity but it is more difficult to handle and to regenerate.

Application and Performance

Activated carbon has been used in a variety of applications involving the removal of objectional organics from wastewater streams. One of the more frequent uses is to reduce the COD and BOD concentration in sanitary treatment system effluents. It is also used to remove specific organic contaminants in the wastewaters of various manufacturing operations such as petroleum refining. There are two full scale activated carbon systems in use in the steel industry treating cokemaking wastes.

Tests performed on single compound systems indicate that processing with activated carbon can achieve residual levels on the order of 1 microgram per liter for many of the organic compounds on the toxic pollutant list. Compounds which respond well to adsorption include carbon tetrachloride, chlorinated benzenes, chlorinated ethanes, chlorinated phenols, haloethers, phenols, nitrophenols, DDT and metabolites, pesticides, polynuclear aromatics and PCB's. Plant scale systems treating a mixture of many organic compounds must be carefully designed to optimize certain critical factors.

Factors which affect overall adsorption of mixed solutes include relative molecular size, the relative adsorptive affinities, and the relative concentration of the solutes. Data indicate that column treatment with granular carbon provides for better removal of organics than clarifier contact treatment with powdered carbon.

Data from two activated carbon column systems used in the steel industry and EPA treatability data for carbon adsorption systems were combined to develop performance standards for carbon column systems. The average concentration values attainable with carbon adsorption systems are shown in Table VI-1 for those toxic organics found above treatability levels in steel industry wastewaters.

Advantages and Limitations

The major benefits of carbon treatment include applicability to a wide variety of organics, and a high removal efficiency. Inorganics such as cyanide, chromium, and mercury are also removed effectively by this system. The system also tolerated variations in concentration and flow rates. The system is compact, and recovery of adsorbed materials is sometimes practical. However, the destruction of adsorbed compounds often occurs during thermal regeneration. If carbon cannot be thermally desorbed, it must be disposed of along with any adsorbed pollutants. When thermal regeneration is used, capital and operating costs are generally economical when carbon usage exceeds about 1,000 lb/day. Carbon cannot remove low molecular weight or highly soluble organics.

Operational Factors

a. Reliability: This system is very reliable assuming upstream protection and proper operation and maintenance procedures.

b. Maintainability: This system requires periodic regeneration or replacement of spent carbon and is dependent upon raw waste load and process efficiency.

Demonstration Status

Carbon adsorption systems have been demonstrated to be practical and economical for the reduction of COD, BOD and related pollutants in secondary municipal and industrial wastewaters; for the removal of toxic or refractory organics from isolated industrial wastewaters; for the removal and recovery of certain organics from wastewaters; and for the removal, at times with recovery, of selected inorganic chemicals from aqueous wastes. Carbon adsorption is considered a viable and economic process for organic waste streams containing up to 1 to 5 percent of refractory or toxic organics. It also has been used to remove toxic inorganic pollutants such as metals.

Granular carbon adsorption is demonstrated at two plants in the cokemaking subcategory. Additionally, a powdered carbon addition study has been piloted at one coke plant, and a full scale granular carbon system is being installed at a blast furnace site.

2. Biological Oxidation

Biological treatment is another method of reducing the concentration of organics from process wastewater. Biological systems, both single and two-stage, have been used effectively to treat sanitary wastes. The activated sludge system is the type of biological system that has been demonstrated in the steel industry, although other systems including rotating biological disks have also been studied.

In the activated sludge process, wastewater is stablized biologically in a reactor under aerobic conditions. The aerobic environment is achieved by the use of diffused or mechanical aeration. After the wastewater is treated in the reactor, the resulting biological mass is separated from the liquid in a settling tank. A portion of the settled biological solids is recycled and the remaining mass is wasted. The level at which the biological mass should be maintained in the system depends upon the desired treatment efficiency, the particular pollutants that are to be removed and other considerations related to growth kinetics.

The activated sludge system generally is sensitive to temperature and various pollutants. Temperature not only influences the metabolic activities of the microbiological population, but also has an effect on such factors as gas transfer rates and the settling characteristics of the biological solids. Some pollutants are extremely toxic to the microorganisms in the system, such as ammonia at high concentrations and metals. Therefore, sufficient pretreatmnet must be installed ahead of the biological reactor so that high levels of toxic pollutants do not enter the system and "kill" the microorganism population. If the biological conditions in an activated sludge plant are upset, it can be a matter of days or weeks before biological activity returns to normal.

Application and Performance

Although a great deal of information is available on the performance of activated sludge units in controlling phenolic compounds, cyanides, ammonia, and BOD, limited long-term data are available regarding toxic pollutants other than phenolic compounds, cyanides, and ammonia. Only lately has there been an emphasis upon the performance of the activated sludge units on the toxic organic pollutants.

Originally, advanced levels of treatment using a biological system were expected to involve multiple stages for accomplishing selective degradation of pollutants in series, e.g., phenolic compounds and cyanide removal, nitrification, and dentrification. The Agency sampled the wastewaters of two well operated biological plants in the coke- making subcategory. Both of these plants achieved good removals of toxic pollutants with organic removal averaging better than 90% and completely eliminating phenolic compounds, napthalene, and xylene. The analytical data for these plants together with EPA treatability data for biological systems were used to develop performance standards for toxic organic pollutants for biological oxidation systems. These standards are shown in Table VI-4 for those toxic pollutants found in the steel industry wastewaters above treatability levels.

Advantages and Limitations

The activated sludge system achieves significant reductions of most organic pollutants at significantly less capital and operating costs than for carbon adsorption. Also, consistent effluent quality can be maintained if sufficient pretreatment is practiced and shock loadings of specific pollutants are eliminated. The temperature of the system must be maintained within certain ranges or fluctuating removal efficiencies of some pollutants will occur.

Operational Factors

a. Reliability: This system is very reliable assuming upstream protection and proper operation and maintenance procedures.

b. Maintainability: As long as adequate pretreatment is practiced, acceptable effluent quality can be maintained. If the system is upset, the operation can be brought under control by seeding with biological floc or POTW sludges.

Demonstration Status

Activated sludge systems are well demonstrated for removing organic constituents from wastewater. Also, eighteen cokemaking plants have various types of biological oxidation systems presently installed.

Advanced Technologies

The Agency considered other advanced treatment technologies as possible alternative treatment systems. Ion exchange and reverse osmosis were considered because of their treatment effectiveness and because, in certain applications, they allow the recovery of certain process material. A discussion of these technologies follows.

1. Ion Exchange

Ion exchange is a process in which ions, held by electrostatic forces to charged functional groups on the surface of the ion exchange resin, are exchanged for ions of similar charge from the solution in which the resin is immersed. This is classified as absorption process because the exchange occurs on the surface of the resin, and the exchanging ion must undergo a phase transfer from solution phase to solid phase. Thus, ionic contaminants in a wastewater can be exchanged for the harmless ions of the resin.

The Wastewater stream passes through a filter which removes suspended solids, and then through a cation exchanger which contains the ion exchange resin. The exchanger retains metallic impurities such as copper, iron, and trivalent chromium. The wastewater then passes through the anion exchanger and its associated resin. Hexavalent chromium, for example, is retained in this stage. If the wastewater is not effectively treated in one pass through it may be passed through another series of exchangers. Many ion exchange systems are equipped with more than one set of exchangers for this reason.

The other major portion of the ion exhcange process concerns the regeneration of the resin, which holds impurities removed from the wastewater. Metal ions such as nickel are removed by an acid cation exchange resin, which is regenerated with hydrochloric or sulfuric acid, replacing the metal ion with one or more hydrogen ions. Anions such as dichromate are removed by a basic anion exchange resin, which is regenerated with sodium hydroxide, replacing the anion with one or more hydroxyl ions. The three principal methods employed by industry for regenerating the spent resin are:

a. Replacement Service: A regeneration service replaces the spent resin with regenerated resin, and regenerates the spent resin at its own facility. The service then treats and disposes of the spent regenerant.

b. In-Place Regeneration: Some establishments may find it less expensive to conduct on-site regeneration. The spent resin column is shut down for perhaps an hour, and the spent resin is regenerated. This results in one or more waste streams which must be treated in an appropriate manner. Regeneration is performed as the resins require it, usually every few months.

c. Cyclic Regeneration: In this process, the regeneration of the spent resins takes place within the ion exchange unit itself in alternating cycles with the ion removal process. A regeneration time permits operation with a very small quantity of resin and with fairly concentrated solutions, resulting in a very compact system. Again, this process varies according to application, but the regeneration cycle generally begins with caustic being pumped through the anion exchanger, which carries out hexavalent chromium, for example, as sodium dichromate. The sodium dichromate stream then passes through a cation exchanger, converting the sodium dichromate to chromic acid. After being concentrated by evaporation or other means, the chromic acid can be returned to the process line. Meanwhile, the cation exchanger is regenerated with sulfuric acid, resulting in a waste acid stream containing the metallic impurities removed earlier. Flushing the exchangers with water completes the cycle. Thus, the wastewater is purified and, in this example, chromic acid is recovered. The ion exchangers, with newly regenerated resin, then enter the ion removal cycle again.

Application and Performance

The list of pollutants for which the ion exchange system has proven effective includes, among others, aluminum, arsenic, cadmium, chromium (hexavalent and trivalent), copper, cyanide, gold, iron, lead, manganese, nickel, selenium, silver, tin, and zinc. Thus, it can be applied to a wide variety of industrial concerns. Because of the heavy concentrations of metals in metal finishing wastewaters, ion exchange is used in several ways in that industry. As an end-of-pipe treatment, ion exchange is certainly feasible, but its greatest value is in recovery applications. It is commonly used as an integrated treatment to recover rinse water and process chemicals. Some electroplating facilities use ion exchange to concentrate and purify plating baths. Also, many industrial concerns use ion exchange to reduce salt concentrations in incoming water sources.

Ion exchange is highly efficient at recovering metal bearing solutions. Recovery of chromium, nickel, phosphate solution, and sulfuric acid from anodizing is commercially viable. A chromic acid recovery efficiency of 99.5 percent has been demonstrated. Ion exchange systems are reported to be installed at three pickling operations, however, none of these systems were sampled during this study. Data for two plants in the coil coating category are shown below.

Ion Exchange Performance

Pollutant	Plant A		Plant B	
All Values mg/l	Prior to Purification	After Purification	Prior to Purification	After Purification
Al	5.6	0.20	-	-
Cd	5.7	0.00	-	-
Cr^{+3}	3.1	0.01	-	-
Cr^{+6}	7.1	0.01	-	-
Cu	4.5	0.09	43.0	0.10
CN	9.8	0.04	3.40	0.09
Au	-	-	2.30	0.10
Fe	7.4	0.01	-	-
Pb	-	-	1.70	0.01
Mn	4.4	0.00	-	-
Ni	6.2	0.00	1.60	0.01
Ag	1.5	0.00	9.10	0.01
SO_4	-	-	210.00	2.00
Sn	1.7	0.00	1.10	0.10
Zn	14.8	0.40	-	-

Advantage and Limitations

Ion exchange is a versatile technology applicable to a great many situations. This flexibility, along with its compact nature and performance, makes ion exchange an effective method of wastewater treatment. However, the resins in these systems can prove to be a limiting factor. The thermal limits of the anion resins, generally placed in the vicinity of 60°C, could prevent its use in certain situations. Similarly, nitric acid, chromic acid, and hydrogen peroxide can all damage the resins as will iron, manganese, and copper when present with sufficient concentrations of dissolved oxygen. Removal of a particular trace contaminant may be uneconomical because of the presence of other ionic species that are preferentially removed. The regeneration of the resins presents its own problems. The cost of the regenerative chemicals can be high. In addition, the waste streams originating from the regeneration process are extremely high in pollutant cncentrations, although low in volume. These must be further processed for proper disposal.

Operational Factors

a. Reliability: With the exception of occasional clogging or fouling of the resins, ion exchange is a highly dependable technology.

b. Maintainability: Only the normal maintenance of pumps, valves, piping and other hardware used in the regeneration process is usually encountered.

Demonstration Status

All of the applications mentioned in this section are available for commercial use, and industry sources estimate the number of units currently in the field at well over 120. The research and development in ion exchange is focusing on improving the quality and efficiency of the resins, rather than new applications. Work is also being done on a continuous regeneration process whereby the resins are contained on a fluid-transfusible belt. The belt passes through a compartmented tank with ion exchange, washing, and regeneration sections. The resins are therefore continually used and regenerated. No such system, however, has been reported to be beyond the pilot stage. Ion exchange is used in at least three different plants in the steel industry. Also, ion exchange is used in a variety of other metal working situations.

2. Reverse Osmosis

The process of osmosis involves the passage of a liquid through a semipermeable membrane from a dilute to a more concentrated solution. Reverse osmosis (RO) is an operation in which pressure is applied to the more concentrated solution, forcing the permeate to diffuse through the membrane and into the more dilute solution. This filtering action produces a concentrate and a permeate on opposite sides of the membrane. The concentrate can then be further treated or returned to the original operation for continued use, while the permeate water can be recycled for use as clean water.

There are three basic configurations used in commercially available RO modules: tubular, sprial-wound, and hollow fiber. All of these operate on the principle described above, the major difference being their mechanical and structural design characteristics.

The tubular membrane module utilizes a porous tube with a cellulose acetate membrane-lining. A common tubular module consists of a length of 2.5 cm (1 inch) diameter tube wound on a supporting spool and encased in a plastic shroud. Feed water is driven into the tube under pressures varying from 40-55 atm (600-800 psi). The permeate passes through the walls of the tube and is collected in a manifold while the concentrate is drained off at the end of the tube. A less widely used tubular RO module used a straight tube contained in a housing, under the same operating conditions.

Spiral-wound membranes consist of a porous backing sandwiched between two cellulose acetate membrane sheets and bonded along three edges. The fourth edge of the composite sheet is attached to a large permeate collector tube. A spacer screen is then placed on top of the membrane sandwich and the entire stack is rolled around the centrally located tubular permeate collector. The rolled up package is inserted into a pipe able to withstand the high operating pressures employed in this process, up to 55 atm (800 psi) with the spiral-wound module. When the system is operating, the pressurized product water permeates the membrane and flows through the backing material to the central collector tube. The concentrate is drained off at the end of the container pipe and can be reprocessed or sent to further treatment facilities.

The hollow fiber membrane configuration is made up of a bundle of polyamide fibers of approximately 0.0075 cm (0.003 in.) OD and 0.0043 cm (0.0017 in.) ID. A commonly used hollow fiber module contains several hundred thousand of the fibers placed in a long tube, wrapped around a flow screen, and rolled into a spiral. The fibers are bent in a U-shape and their ends are supported by an epoxy bond. The hollow fiber unit is operated under 27 atm (400 psi), the feed water being dispersed from the center of the module through a porous distributor, tube. Permeate flows through the membrane to the fibers hollow interiors and is collected at the ends of the fibers.

The hollow fiber and spiral-wound modules have a distinct advantage over the tubular system in that they are able to load a very large membrane surface area into a relatively small volume. However, these two membrane types are much more susceptible to fouling than the tubular system, which has a larger flow channel. This characteristic also makes the tubular membrane much easier to clean and regenerate than either the spiral-wound or hollow fiber modules. One manufacturer claims that their helical tubular module can be physically wiped clean by passing a soft porous polyurethane plug under pressure through the module.

Application and Performance

In a number of metal processing plants, the overflow from the first rinse in a countercurrent setup is directed to a reverse osmosis unit, where it is separated into two streams. The concentrated stream contains dragged out chemicals and is returned to the bath to replace the loss of solution due to evaporation and dragout. The dilute stream (the permeate) is routed to the last rinse tank to provide water for the rinsing operation. The rinse flows from the last tank to the first tank and the cycle is complete.

The closed-loop system described above may be supplemented by the addition of a vacuum evaporator after the RO unit in order to further reduce the volume of reverse osmosis concentrate. The evaporated vapor can be condensed and returned to the last rinse tank or sent on for further treatment.

The largest application has been for the recovery of nickel solutions. It has been shown that RO can generally be applied to most acid metal baths with a high degree of performance, providing that the membrane unit is not overtaxed. The limitations most critical here are the allowable pH range and maximum operating pressure for each particular configuration. Adequate prefiltration is also essential. Only three membrane types are readily available in commercial RO units, and their overwhelming use has been for the recovery of various acid metal baths. For the purpose of calculating performance predictions of this technology, a rejection rate of 98 percent is assumed for dissolved salts, with 95 percent permeate recovery.

Advantages and Limitations

The major advantage of reverse osmosis for treating wastewaters is its ability to concentrate dilute solutions for recovery of salts and chemicals with low power requirements. No latent heat of vaporization or fusion is required for effecting separations; the main energy requirement is for a high pressure pump. It requires relatively little floor space for compact, high capactiy units, and it exhibits good recovery and rejection rates for a number of typical process solutions. A limitation of the reverse osmosis process is its limited temperature range for satisfactory operation. For cellulose acetate systems, the preferred limits are 18 to 30°C (65 to 85°F); higher temperatures will increase the rate of membrane hydrolysis and reduce system life, while lower temperatures will result in decreased fluxes with no damage to the membrane. Another limitation is the inability to handle certain solutions. Strong oxidizing agents, strong acidic or basic solutions, solvents, and other organic compounds can cause dissolution of the membrane. Poor rejection of some compounds such as borates and low molecular weight organics is another problem. Fouling of membranes by failures, and fouling of membranes by wastewaters with high levels of suspended solids can be a problem. A final limitation is the inability to treat or achieve high concentration with some solutions. Some concentrated solutions may have initial osmotic pressures which are so high that they either exceed available operating pressures or are uneconomical to treat.

Operational Factors

a. Reliability: Very good reliability is achieved so long as the proper precautions are taken to minimize the chances of fouling or degrading the membrane. Sufficient testing of the waste stream prior to application of an RO system will provide the information needed to insure a successful application.

b. Maintainability: Membrane life is estimated to fall between 6 months and 3 years, depending on the use of the system. Down time for flushing or cleaning is on the order of two hours as often as once each week; a substantial portion of maintenance time must be spent on cleaning any prefilters installed ahead of the reverse osmosis unit.

Demonstration Status

There are presently at least one hundred reverse osmosis wastewater applications in a variety of industries. In addition to these, there are thirty to forty units being used to provide pure process water for several industries. Despite the many types and configurations of membranes, only the spiral-wound cellulose acetate membrane has had widespread success in commercial applications. There are no known RO units presently in operation in the steel industry.

Zero Discharge Technologies

Zero discharge of process water is achieved in several subcategories of the steel industry in a variety of ways. The most commonly used method is to treat the waste sufficiently so it can be completely reused in the originating process or to control water application in semi-wet air pollution control systems so that no discharge results. This method is used principally in steelmaking. Since recycle systems were discussed earlier in this section, no further details are presented here.

Another potential means to achieve zero discharge is by the use of evaporation technology. Evaporation systems concentrate the wastewater constituents and produce a distillate quality water that can be recycled to the process. Although this technology is very costly and energy intensive, it may be the only treatment method available that allows the universal attainment of zero discharge in many steel industry subcategories. Details on various types of evaporation technology are discussed below.

A third method to achieve zero discharge has been demonstrated in the ironmaking subcategory: quenching. In quenching systems, flows are reduced and the blowdown from the operation is used to quench (cool) slag. The wastewater is eliminated by evaporation on the hot slag. This system is relatively inexpensive and can be used at many ironmaking operations. However, it does result in some air emissions which can contain particulates and other contaminants. Since this technology is specific mainly to ironmaking, it is discussed in detail in the ironmaking subcategory report.

Evaporation

Evaporation is a concentration process. Water is evaporated from a solution, increasing the concentration of solute in the remaining solution. If the resulting water vapor is condensed back to liquid water, the evaporation-condensation process is called distillation. However evaporation is used in this report to describe both processes. Both atmospheric and vacuum evaporation are commonly used in industry today. Atmospheric evaporation could be accomplished simply by boiling the liquid. However, to aid evaporation, heated liquid is sprayed on an evaporation surface, and air is blown over the surface and subsequently released to the atmosphere. Thus, evaporation occurs by humidification of the air stream, similar to a drying process. Equipment for carrying out atmospheric evaporation is quite similar for most applications. The major element is generally a packed column with an accumulator bottom. Accumulated wastewater is pumped from the base of the column, through a heat exchanger, and back into the top of the column, where it is sprayed into the packing. At the same time, air drawn upward through the packing by a fan is heated as it contacts the hot liquid. The liquid partially vaporizes and humidifies the air stream. The fan then blows the hot, humid air to the outside atmosphere. A scrubber is often unnecessary because the packed column itself acts as a scrubber.

Another form of atmospheric evaporator also works on the air humidification principle, but the evaporated water is recovered for reuse by condensation. These air humidification techniques operate well below the boiling point of water and can use waste process heat to supply the energy required.

In vacuum evaporation, the evaporation pressure is lowered to cause the liquid to boil at reduced temperature. All of the water vapor is condensed and, to maintain the vacuum condition, noncondensible gases (air in particular) are removed by a vacuum pump. Vacuum evaporation may be either single or double effect. In double effect evaporation, two evaporators are used, and the water vapor from the first evaporator (which may be heated by steam) is used to supply heat to the second evaporator. As it supplies heat, the water vapor from the first evaporator condenses. Approximately equal quantities of wastewater are evaporated in each unit; thus, the double effect system evaporates twice the amount of water that a single effect system does, at nearly the same cost in each unit; thus, the double effect system evaporates twice the amount of water that a single effect system does, at nearly the same cost in energy but with added capital cost and complexity. The double effect technique is thermodynamically possible because the second evaporator is maintained at lower pressure (high vacuum) and, therefore, lower evaporation temperature. Another means of increasing energy efficiency is vapor recompression (thermal or mechanical), which enables heat to be transferred from the condensing water vapor to the evaporating wastewater. Vacuum evaporation equipment may be classified as sumberged tube or climbing film evaporation units.

In the most commonly used submerged tube evaporator, the heating and condensing coil are contained in a single vessel to reduce capital cost. The vacuum in the vessel is maintained by an ejector-type pump, which creates the required vacuum by the flow of the condenser cooling water through a venturi. Wastewater accumulates in the bottom of the vessel, and it is evaporated by means of submerged steam coils. The resulting water vapor condenses as it contacts the condensing coils in the top of the vessel. The condensate then drips off the condensing coils into a collection trough that carries it out of the vessel. Concentrate is removed from the bottom of the vessel.

The major elements of the climbing film evaporator are the evaporator, separator, condenser, and vacuum pump. Wastewater is "drawn" into the system by the vacuum so that a constant liquid level is maintained in the separator. Liquid enters the steam-jacketed evaporator tubes, and part of it evaporates so that a mixture of vapor and liquid enters the separator. The design of the separator is such that the liquid is continuously circulated from the separator to the evaporator. The vapor entering the separator flows out through a mesh entrainment separator to the condenser, where it is condensed as it flows down through the condenser tubes. The condensate, along with any entrained air, is pumped out of the bottom of the condenser by a liquid ring vacuum pump. The liquid seal provided by the condensate keeps the vacuum in the system from being broken.

Application and Performance

Both atmospheric and vacuum evaporation are used in many industrial plants, mainly for the concentration and recovery of process solutions. Many of these evaporators also recover water for rinsing. Evaporation has also been used to recover phosphate metal cleaning solutions.

Advantages and Limitations

Advantages of the evaporation process are that it permits recovery of a wide variety of process chemicals, and it is often applicable to concentration or removal of compounds which cannot be accomplished by any other means. The major disadvantage is that the evaporation process consumes relatively large amounts of energy. However, the recovery of waste heat from many industrial processes (e.g., diesel generators, incinerators, boilers and furnaces) should be considered as a source of this heat for a totally integrated evaporation system. Also, in some cases solar heating could be inexpensively and effectively applied to evaporation units. For some applications, pretreatment may be required to remove solids or bacteria which tend to cause fouling in the condenser or evaporator. The buildup of scale on the evaporator surfaces reduces the heat transfer efficiency and may present a maintenance problem or increase operating cost. However, it has been demonstrated that fouling of the heat transfer surfaces can be avoided or minimized for certain dissolved solids by precipitate deposition. In addition, low temperature differences in the evaporator will eliminate nucleate boiling and supersaturation effects. Steam distillable impurities in the process stream are carried over with the product water and must be handled by pre or post-treatment.

Operational Factors

1. Reliability: Proper maintenance will ensure a high degree of reliability for the system. Wthout such attention, rapid fouling or deterioration of vacuum seals may occur, especially when handling corrosive liquids.

2. Maintainability: Operating parameters can be automatically controlled. Pretreatment may be required, as well as periodic cleaning of the system. Regular replacement of seals, especially in a corrosive environment, may be necessary.

Demonstration Status

Evaporation is a fully developed, commercially available wastewater treatment system. It is used extensively to recover plating chemicals in the electroplating industry and a pilot scale unit has been used in connection with phosphating of aluminum. Aside from quenching systems, evaporation technology is not used in steel industry applications for wastewater treatment.

C. In-Plant Controls and Process Modifications

The use of in-plant technology in the steel industry is designed to reduce or eliminate the waste load requiring end-of-pipe treatment and thereby improve the efficiency of existing waste treatment systems or reduce the requirements of a new treatment system. In-plant technologies demonstrated in the steel industry includes alternate rinsing procedures, water conservation, reduction of dragout, automatic controls, good housekeeping practices, recycle of untreated process waters and process modifications.

1. In-Process Treatment and Controls

In-process treatment and controls apply to both existing and new installations and include existing technologies and operating practices. The data received from the industry indicates that water conservation practices are widely used in many subcategories. Within any particular subcategory it is not unusual to find process flows varying by orders of magnitude. In many cases, these variations are directly related to in-process water conservation and control measures. Although the proposed effluent limitations do not regulate flow, they are based on model flow rates demonstrated in the respective subcategories.

While tighter control over operating practices is one type of in-plant control, others are more involved and require greater expenditures of capital. One of these is the installation of counter-current rinsing system. Counter-current rinsing is a demonstrated in-process control for pickling operations and may be implemented at other processes that use conventional rinsing techniques.

Another in-process control is the recycle of process water. In several steel industry processes, wastewaters are recycled "in- plant" even prior to treatment. For example, in the cold rolling process, oil emulsions can be collected and returned to the mill in recirculation systems thereby reducing the volumes of wastewater discharged. This control method may not necessarily be used in all processes because of the product quality or recycle system problems that may be encountered.

Other simple in-process controls that can affect discharge quality include good housekeeping practices and automatic equipment. For example, if tight control over the process is maintained and spills are controlled, excessive "dumps" of waste solutions can be averted. Also, automatic controls can be installed that control applied water rates to insure that water is applied only when a mill is actually operating. For mills which do not operate every turn or every day of the year, the water which is conserved with this practice can be considerable.

2. Process Substitutions

There are several instances in the steel industry where process substitutions can effectively control wastewater discharges. One is a cold rolling operations where mills can be designed to operate either in a once-through or recycle mode. If those mills with once-through systems operated in a recycle mode, oil usage can be reduced and savings could be achieved since a smaller treatment system would be required.

Another area where in-process substitutions can achieve significant reductions in wastewater flows and loads is by selecting or converting from a wet or semi-wet air cleaning operation to a dry system.

As a final matter, substitution of process solutions can be used to reduce levels of pollutants that are considered harmful. For example, certain rolling solutions have been found to contain high levels of toxic organic pollutants. Data gathered for this study indicate that not all rolling solutions contain high levels of these compounds. Therefore, instead of installing costly treatment for the organic consitutuents, a substitution of rolling solutions to another acceptable oil will correct the problem of high levels of toxics at little or no cost.

TABLE VI-1

TOXIC ORGANIC CONCENTRATIONS ACHIEVABLE BY TREATMENT

No.	Priority Pollutant	Achievable Concentration(μg/l)	
		Carbon Adsorption	Biological Oxidation(1)
003	Acrylonitrile	200	100
004	Benzene	50	50
009	Hexachlorobenzene	1	*
011	1,1,1-Trichloroethane	100	*
021	2,4,6-Trichlorophenol	25	50
022	Parachlorometacresol	50	*
023	Chloroform	20	200
024	2-Chlorophenol	50	50
034	2,4-Dimethylphenol	25	5
035	2,4-Dinitrotoluene	50	50
036	2,6-Dinitrotoluene	50	100
038	Ethylbenzene	50	25
039	Fluoranthene	10	5
054	Isophorone	50	100
055	Naphthalene	25	5
057	2-Nitrophenol	25	100
060	4,6-Dinitro-o-cresol	25	25
064	Pentachlorophenol	50	*
065	Phenol	50	25
066-071	Phthalates, Total	100	200
072	Benzo(a)anthracene	10	5
073	Benzo(a)pyrene	1	5
076	Chrysene	5	10
077	Acenaphthylene	10	10
078	Anthracene	1	1
080	Fluorene	10	5
084	Pyrene	10	10
085	Tetrachlorethylene	50	100
086	Toluene	50	50
130	Xylene	10	100

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* No siginificant removal over influent level.
(1) Two-stage activated sludge system.

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SECTION VII

DEVELOPMENT OF COST ESTIMATES

Introduction

This section reviews the methodology used to develop cost estimates for the alternative treatment systems for each subcategory. The impacts due to these costs and to other factors such as energy and solid waste disposal, are reviewed elsewhere.

Basis of Cost Estimates

Costs developed for the various levels of treatment (i.e., BPT, BAT, BCT, NSPS and Pretreatment) are presented in the individual reports for each subcategory. Model cost includes investment, capital depreciation, interest, operating and maintenance, and energy. The costs for BPT and BAT are summarized and presented in Sections VIII and IX of this report. Costs for PSES are included in those for BPT and BAT while only model costs are presented for NSPS and PSNS. The Agency did not include estimates of capacity additions in this report. However, estimates of capacity additions, retirements, and reworks are included in Economic Analysis of Proposed Effluent Guidelines - Integrated Iron and Steel Industry, and the likely economic impact of NSPS and PSNS are included in that study.

For each subcategory the model costs were developed as follows:

1. National annual production and capacity data were collected and tabulated along with the number of plants in each subcategory. From this, an "average" plant size was established.

2. Where more than one mill existed at one plant site, the capacities of these mills were summed to develop a site size. This manner of sizing model plants more accurately represented the actual treatment practices at a steel plant. Wastewaters from all cold mills at a given site will usually be treated in one central treatment system. By using site sizes, where appropriate, central treatment within subcategories was more accurately reflected in the cost estimates.

3. If different product types or steel types were found to have different average sizes, separate cost models were developed to more accurately define the costs for these groupings.

4. Applied flow rates were established based upon data obtained from questionnaires and accumulated during field sampling visits. The model flows are expressed in l/kkg or gal/ton of product.

5. A treatment process model and flow diagram was developed for each subcategory based upon appropriate subcategory treatment systems

and flow rates incorporating the application of good water pollution control practice.

6. Finally, a detailed cost estimate was made on the basis of the alternative treatment system.

Total annual costs were developed by adding the operating costs (including all chemicals, maintenance, labor, and energy) and the capital recovery costs. Capital recovery costs consist of the depreciation and interest charges based upon a ten year straight line depreciation and a 7% interest rate, respectively. All costs were developed in July, 1978 dollars.

The capital recovery factor (CRF) is normally used in industry to help allocate the initial investment and the interest of the total operating cost of a facility. The CRF is calculated as follows and is multiplied by the initial investment to obtain the capital recovery cost:

$$\mathrm{CRF} = \frac{1 + i}{a - 1}$$

Where,

$a = (1 + i)^n$
i = interest rate
n = number of years

The annual depreciation is found by dividing the initial investment by the depreciation period (n = 10 years). That is, $p/10$ = annual depreciation. Then the annual cost of capital has been assumed to be the total annual capital recovery (ACR) minus the annual depreciation. That is, $\mathrm{ACR} - p/10$ = annual cost of capital.

Construction costs are highly variable and in order to determine consistent costs, the following parameters were established as the basis of estimates. In addition, the cost estimates reflect only average costs.

1. The treatment facilities are contained within a "battery limit" site location and are erected on a "green field" site. Site clearance costs have been estimated based on average site conditions with no allowances for equipment relocation.

2. Equipment costs are based upon specific effluent water rates. A change in water flow rates will affect costs.

3. The treatment facilities are located in reasonable proximity to the "source" process area. Piping and other utility costs for interconnecting utility runs between the treatment facilities' battery limits and process equipment areas are based on moderate linear distances for these cost estimates.

4. Land acquisition costs are not specifically included in the cost estimates. However, these costs are specifically included as

part of the economic analysis that accompanies this proposed regulation.

5. Limited instrumentation has been included for pH and ORP control, but automatic samplers, temperature indicators, flow meters, recorders, etc., have not been included in the cost estimates.

6. Control buildings are prefabricated buildings; not brick or block type.

In general, the cost estimates reflect an on-site "battery limit" treatment plant with electrical substation and equipment for powering the facilities, all necessary pumps, treatment plant interconnecting feed pipe lines, chemical treatment facilities, foundations, structural steel, and a control house. Access roadways within battery limits are included in estimates based upon 3.65 cm (1.5 inch) thick bituminous wearing course and 10 cm (4 inch) thick sub-base with sealer, binder, and gravel surfacing. A nine gauge chain link fence with three strand barb wire and one truck gate were included for fencing. The cost estimates also include a 15% contingency, 10% contractor's overhead and profit, and engineering fees of 15%.

Application of Co-mingling Factors

The Agency has concluded that central treatment systems are the least costly way to treat wastewaters with similar pollutant characteristics. However, treatment costs have previously been developed strictly from the model plant approach with little consideration of the cost savings achieved with the central treatment systems.

For this study, estimates were made of the savings achieved by joint treatment of wastes within subcategories so that cost projections for the industry will be more accurate. For example, in the hot forming subcategory, an inventory was completed which detailed where joint treatment systems exist and what types of hot forming wastes are combined. The cost reductions achieved with these joint systems were calculated on a percentage basis. First a cost estimate was developed assuming all plants employed separate treatment. Next, a cost estimate was completed based upon actual treatment practices. For example, if wastewaters from a primary mill and a section mill were combined for treatment, the combined treatment system was costed. This type of costing was done plant by plant and subdivision by subdivision. The costs for the subdivision calculated on the basis of central treatment systems were then divided by the costs for the subdivision developed on the basis of separate treatment to calculate the co-mingling factor for that subdivision. These factors account for cost reductions achieved with the central treatment systems and were used to more accurately develop the BPT, BCT, and BAT cost estimates for the hot forming subcategory.

However, central treatment across subcategories (i.e. pickling and cold rolling, or hot forming and steelmaking), were not considered although multi-subcategory central treatment systems are common in the industry.

BPT Cost Estimates

Two BPT cost estimates were made for this study. The first deals with the capital costs for the BPT systems already installed and the second accounts for the capital costs for the BPT treatment components still required. Only total annual costs are reported since annual expenditures already made will continue to operate the installed treatment systems.

Because DCP responses were received from all major steel operations and almost all minor steel facilities, the data base on installed treatment components (as of January 1, 1978) is fairly complete. Using this data base, a plant-by-plant inventory was completed which tabulated the treatment components presently installed and those components which are required to bring the systems up to the BPT treatment level. Hence, an estimate of capital cost requirements was made for each plant and subcategory by scaling individual plants to the developed treatment model and factoring costs based on production by the "six-tenth factor". By this method, the Agency estimated the expenditures already made by the steel industry. These data were summarized earlier in Section II, and are presented for each subcategory in Table VIII-1.

The Agency then estimated the expenditures needed to bring the facilities from current treatment levels to a level from which they can then install BAT technology; this level is referred to as the "BAT Feed Level". These costs were considered as "BPT Required" costs for purposes of the economic impact of the industry. The "BAT Feed Level" is identical to the BPT level, treatment wise. However, for some subcategories, the BAT feed level has model flow rates different from model BPT discharge flows. As pointed out earlier, the new data base has shown that some of the flow rates used as the basis of the 1974 and 1976 BPT limitations are not representative of actual operations. Even though the Agency has decided not to revise the BPT limitations, the most accurate flow rates were used for costing purposes. In this way, cost estimates made for the industry are more accurate and thus estimated economic impacts that may result from achievement of the effluent limitations will be more realistic.

BAT, BCT, NSPS, PSES, and PSNS Cost Estimates

The capital and annual cost estimates for these treatment levels were derived by multiplying the number of plants in a subcategory by the approximate model costs for that level. For BAT and BCT levels, the total number of plants (including those discharging to POTWs) were multiplied by the model costs. These costs are summarized in Table IX-2. For NSPS and PSNS, total industry costs have not been presented since predictions of future expansion in the industry were not made as part of this study. As noted above, the PSES costs are included in the BPT and BAT cost totals. Model costs for these treatment levels are presented in the respective subcategory reports.

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SECTION VIII

EFFLUENT QUALITY ATTAINABLE THROUGH THE APPLICATION OF THE BEST PRACTICABLE CONTROL TECHNOLOGY CURRENTLY AVAILABLE

Introduction

Best Practicable Control Technology Currently Available (BPT) is generally based upon the average of the best existing performance by mills of various sizes, ages, and unit processes within the industrial subcategory. This average is not based upon a broad range of mills within the subcategory, but is based upon performance levels achieved by mills known to be equipped with the best treatment facilities. Experience has demonstrated that in most instances these facilities were effective in the control of only some of the pollutants present.

The Agency also considered the following factors:

1. The size and age of equipment and facilities involved.

2. The processes employed.

3. Nonwater quality environmental impacts (including sludge generation and energy requirements).

4. The engineering aspects of the applications of various types of control techniques.

5. Process changes.

6. The total cost of application of technology in relation to the effluent reduction benefits to be achieved from such application.

BPT emphasizes treatment facilities at the end of a manufacturing process but can also include control technologies within the process itself when they are considered to be normal practice within an industry.

The Agency also considered the degree of economic and engineering reliability in order to determine whether a technology is "currently available." As a result of demonstrations, projects, pilot plants and general use, there must exist a high degree of confidence in the engineering and economic practicability of the technology at the time of commencement of construction or installation of the control facilities.

Identification of BPT

General Discussion

Many types of treatment components and facilities are used within the steel industry. While wide differences in components were noted between the different subcategories, there were also variations in treatment practices within any one subcategory.

End-of-pipe treatment is used in most steel industry subcategories, that is, the entire wastewater flow is treated in a treatment system separate from the process. In these systems, no consideration was given to internal recycle systems or in-line process changes. However, in some subcategories the most significant pollutant load reductions are achieved with recycle systems (blast furnaces and hot forming operations) or in-line modifications (fume scrubber recycle systems at pickle lines). Treatment systems proposed for BPT acknowledged these variations in treatment methods and considered only those mills that have the best treatment systems. In this way, inadequate treatment methods were not included in the development of the proposed BPT limitations.

In most subcategories physical-chemical treatment is used to achieve pollutant reductions. Common methods include neutralization and chemical precipitation, and sedimentation and/or filtration. This last step (sedimentation/filtration) showed the widest variation within the industry with numerous types of devices in use. Some of these include scale pits, flocculation and plate type clarifiers, thickeners, settling lagoons or basins, gravity and pressure filters, and mixed-media and sand filters. Because of the wide variations, the appropriate technology was selected individually by subcategory taking into consideration such factors as usage within the subcategory; removal efficiencies; and, cost and land requirements. Both physical-chemical and biological treatment are used for cokemaking wastes.

Summary of BPT Modifications

As discussed in Section II, the proposed effluent limitations for BPT are identical to the previously promulgated limitations except where they could not be supported. Based upon a review of all currently available data, the Agency believes many of the BPT limitations could be revised and proposed at more stringent levels. However, more stringent BPT limitations are not being proposed at this time.

In the following subcategories, BPT limitations have been relaxed from those originally promulgated: cokemaking, sintering, and open hearth (wet). In addition new subdivisions to certain subcategories have been added to account for variations in flow, wastewater quality or operating mode that were not recognized at the time the previous regulations were developed. These changes are summarized below.

1. Creation of a subdivision for batch sulfuric acid pickling operations where neutralization of wastewaters is practiced.

2. Development of separate limitations for cold working pipe and tube operations.

3. Creation of a subdivision for semi-wet open hearth operations.

4. Creation of a segment for galvanizing operations that coat wire products and fasteners.

5. Creation of a hot coating subdivision to cover those operations that carry out other than galvanizing or terne coating.

Proposed BPT Effluent Limitations

Table I-1 summarizes the 1974 and 1976 BPT limitations, along with the changes that are proposed. Where no changes are noted, proposed limitations are the same as the original limitations. The guidelines are based on mass limitations in kilograms per 1000 kilograms (lbs/1000 lbs). As noted earlier, the mass limitations do not require the attainment of any particular discharge flow or effluent concentration. There are virtually an infinite number of combinations of flow and concentration that can be used to achieve the appropriate limitations. This is illustrated in Figure VIII-1 which shows the proposed BPT limitation for suspended solids for the blast furnace subcategory. Also shown on this figure are the relative positions of the sampled plants, some of which are in compliance and some of which did not achieve the limitations. As shown by this diagram, those plants that do not presently achieve the discharge limitation could do so by reducing either discharge flow or effluent concentration, or a combination of the two.

Costs to Achieve the Proposed BPT Limitations

Based upon the cost estimates presented herein, the industry-wide investment costs to achieve full compliance with the proposed BPT limitations is approximately $2.3 billion (in July 1, 1978 dollars). As of January 1, 1978, about $0.75 billion of this amount remained to be spent by the industry as it existed at the time that data were collected. A total annual costs associated with the BPT investment is about $0.30 billion. A breakdown of these BPT costs by subcategory is presented in Table VIII-1. As pointed out in Section II, EPA believes the pollution reduction benefits from compliance with the proposed BPT limitations systems justify the associated costs.

TABLE VIII-1

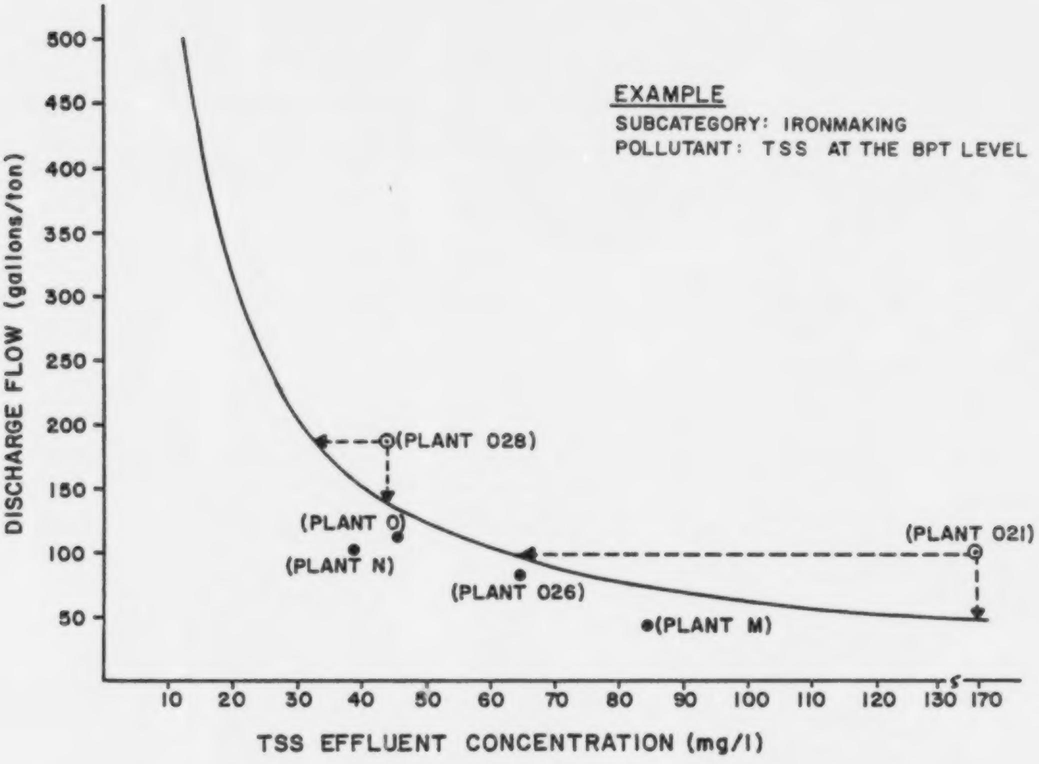
BPT COST ESTIMATIONS
IRON & STEEL INDUSTRY

	Costs (Millions of 7/1/78 Dollars)(1)		
	Capital		
Subcategory	In-Place	Required	Total Annual
A. Cokemaking			
1. By-Product	178.00	125.20	104.90
2. Beehive	0.78	0	0.06
B. Sintering	46.34	27.94	37.26
C. Ironmaking	351.88	122.25	95.28
D. Steelmaking			
1. BOF	89.41	17.92	24.61
2. Open Hearth	16.68	3.02	4.66
3. Electric Arc Furnace	21.71	3.07	8.75
E. Vacuum Degassing	9.91	20.38	7.65
F. Continuous Casting	60.71	41.90	23.90
G. Hot Forming	541.70	135.26	-103.70
H. Scale Removal			
1. Kolene	3.18	3.41	1.83
2. Hydride	0.63	0.26	0.32
I. Acid Pickling			
1. Sulfuric Acid	48.32	89.33	48.01
2. Hydrochloric Acid	63.47	60.92	7.06
3. Combination Acid	26.96	20.56	12.89
J. Cold Forming			
1. Cold Rolling	22.04	30.33	9.70
2. Pipe and Tube	9.20	6.60	2.90
K. Alkaline Cleaning	6.56	7.06	4.15
L. Hot Coatings			
1. Galvanizing	23.87	31.55	11.20
2. Terne	1.16	2.58	0.72
3. Other Coatings	3.10	1.68	0.89
TOTALS	1,525.60	751.22	303.04

NOTE: Costs can be converted to January 1, 1980 dollars by multiplying by 1.17.

(1) Basis: Facilities in place or committed as of 1/1/78.

FIGURE VIII-1
POTENTIAL FOR ACHIEVING
AN EFFLUENT LIMITATION



———: SOLID LINE REPRESENTS TSS LIMIT OF 0.026 kg/kkg (lbs/1000 lbs)

NOTE: PLANTS ABOVE THE SOLID LINE DO NOT MEET TSS LIMITATIONS. HOWEVER, THEY COULD ATTAIN THE APPROPRIATE LOAD BY EITHER REDUCING THEIR FLOW OR EFFLUENT CONCENTRATION AS SHOWN BY THE DASHED ARROWS OR ANY COMBINATION OF THE TWO.

SECTION IX

EFFLUENT QUALITY ATTAINABLE THROUGH THE APPLICATION OF THE BEST AVAILABLE TECHNOLOGY ECONOMICALLY ACHIEVABLE

Introduction

The effluent limitations which must be achieved by July 1, 1984 are to specify the degree of effluent reduction attainable through the application of the best available technology economically achievable. Best available technology is not based upon an average of the best performance within an industrial category, but is determined by identifying the best control and treatment technology employed by a specific point source within the industrial subcategory. Also, where a technology is readily transferable from one industry to another, such technology may be identified as BAT technology.

Consideration was also given to:

1. The size and age of equipment and facilities involved.
2. The processes employed.
3. Non-water quality environmental impact (including energy requirements).
4. The engineering aspects of the application of various types of control techniques.
5. Process changes.
6. The cost of achieving the effluent reduction resulting from application of BAT technology.

Best available technology assesses the availability in all cases of in-process changes or controls which can be applied to reduce waste loads, as well as additional treatment techniques which can be applied at the end of a production process. Those processes and control techniques which at the pilot plant, semi-works, or other level, have demonstrated both sufficient technological performance and economic viability may be considered in assessing best available technology.

Best available technology may be the highest degree of control technology that has been achieved or has been demonstrated to be capable of being designed for plant scale operation up to and including "no discharge" of pollutants. Although economic factors are considered in the development, the level of control is intended to be the top-of-the-line current technology, subject to limitations imposed by economic and engineering feasibility. However, this level may be characterized by some technical risk with respect to performance and with respect to certainty of costs.

Treatment Systems Considered for BAT

To reduce the levels of nonconventional, nontoxic, and toxic pollutants present in the discharge from the industry, fourteen treatment systems were considered either alone or in combination for BAT. A list of these alternatives and the subcategories in which they are being considered are summarized in Table X-1. Detailed explanations of these alternatives are presented in the individual subcategory reports.

Identification of the Best Available Technology

Based upon the information contained in Sections II through VIII of this report and upon data contained in the respective subcategory reports, various treatment systems are being considered for the BAT level of treatment. A short description of the BPT/BAT feed treatment systems and the model BAT treatment systems, if any are considered, is presented in Table I-6. The effluent limitations associated with the model BAT systems are summarized in Table I-3. The costs associated with the model BAT systems are summarized in Table IX-2 by subcategory. As with the proposed BPT effluent limitations, the Agency has concluded the effluent reduction benefits associated with the proposed BAT effluent limitations justify the costs and nonwater quality environmental impacts, including energy consumption, water consumption, air pollution, and solid waste generation.

TABLE IX-1

ADVANCED TREATMENT SYSTEMS CONSIDERED
FOR BAT
IRON AND STEEL INDUSTRY

Advanced Treatment System	Coke-Making	Sintering	Blast Furnace	Basic Oxygen Furnace	Open Hearth	Electric Arc	Vacuum Degassing	Cont. Casting	Hot Forming	Scale Removal	H2SO4 Pickling	HCL Pickling	Comb Pickling	Cold Forming	Alkaline Cleaning	Hot Coating
Acid Recovery/ Regeneration											X	X				
Activated Sludge System	X															
Alkaline Chlorination		X	X													
Cascade Rinse System											X	X	X			X
Evaporation										X	X	X	X	X		X
Evaporation as Quench	X															
Evaporation on Slag			X													
Filtration (Pressure or Gravity)	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X
Granular Carbon Columns	X	X	X											X		
Lime Precipitation	X		X	X	X	X	X									
Powdered Carbon Addition	X													X		
Recycle System	X	X	X	X	X	X			X		X	X	X			X
Sulfide Precipitation		X	X	X	X	X	X	X	X	X	X	X	X			X

TABLE IX-2

BAT COST ESTIMATIONS(1)
IRON & STEEL INDUSTRY

		Costs (Millions of 7/1/78 Dollars)		
		Capital		
Subcategory	Alternative Selected	In Place	Required	Total Annual
A. Cokemaking				
1. By-Product	BAT 1	11.90	45.40	9.76
2. Beehive	BPT	0	0	0
B. Sintering	BAT 3	2.00	11.30	2.60
C. Ironmaking	(2)	4.28	20.58	4.92
D. Steelmaking				
1. BOF				
a. Semi-wet	BPT	0	0	0
b. Wet: Suppressed combustion	BAT 2	0.32	2.22	0.49
c. Wet: Open combustion	BAT 2	0.42	7.68	1.59
2. Open Hearth				
a. Semi-wet	BPT	0	0	0
b. Wet	BAT 2	0	2.36	1.14
3. Electric Arc Funace				
a. Semi-wet	BPT	0	0	0
b. Wet	BAT 2	0.14	2.01	0.40
E. Vacuum Degassing	BAT 1	0.06	1.02	0.20
F. Continuous Casting	BAT 1	0	4.35	0.78
G. Hot Forming	BAT 1	100.80	434.70	110.80
H. Scale Removal				
1. Kolene	BAT 1	0.14	2.52	0.48
2. Hydride	BAT 1	0	0.56	0.10

TABLE IX-2
BAT COST ESTIMATIONS
IRON & STEEL INDUSTRY
PAGE 2

		Costs (Millions of 7/1/78 Dollars)		
		Capital		
Subcategory	Alternative Selected	In Place	Required	Total Annual
I. Pickling				
1. Sulfuric Acid				
a. Acid Recovery	BPT	0	0	0
b. Neutralization	BAT-1	0	9.05	2.89
2. Hydrochloric Acid				
a. Acid regeneration	BAT 1	0	3.06	0.99
b. Neutralization - Batch	BAT 1	0	0.42	0.14
c. Neutralization - Continuous	BAT 1	0	8.99	2.79
3. Combination Acid				
a. Batch	BAT 1	0	3.50	1.00
b. Continuous	BAT 1	0	2.66	0.76
J. Cold Forming				
1. Cold Rolling				
a. Recirculation	BAT-1(3)	0	6.07	1.10
b. Combination	BAT-1(3)	0	5.39	1.04
c. Direct application	BAT-1	0	12.48	2.40
2. Pipe and Tube	BPT	0	0	0
K. Alkaline Cleaning	BPT	0	0	0
L. Hot Coatings				
1. Galvanizing	BAT 1	3.81	5.94	2.88
2. Terne	BAT 1	0.12	0.69	0.23
3. Other Coatings	BAT 1	0	0.57	0.18
TOTALS		123.99	593.52	149.66

---

(1) All BAT costs are over and above BPT cost requirements.
(2) Costs are based on 60% of the plants at BAT 1, and 40% of the plants at the BAT 4 level.
(3) BAT-2 effluent limitations will apply. See cold rolling document for explanation.

NOTE: Costs can be converted to January 1, 1980 dollars by multiplying by 1.17.
Basis: Facilities in place or committed as of 1/1/78.

VOLUME I

SECTION X

BEST CONVENTIONAL POLLUTANT CONTROL TECHNOLOGY (BCT)

Introduction

The 1977 Amendments added Section 301(b)(4)(E) to the Act, establishing "best conventional pollutant control technology" (BCT) for discharges of conventional pollutants from existing industrial point sources. Conventional pollutants are those defined in Section 308(b)(4) - BOD, TSS, fecal coliform and pH - and any additional pollutants defined by the Administrator as "conventional." On July 28, 1978, EPA proposed that COD, oil and grease, and phosphorus be added to the conventional pollutant list (43 Fed. Reg. 32857). Only oil and grease was added.

BCT is not an additional limitation, but replaces BAT for the control of conventional pollutants. BCT requires that limitations for conventional pollutants be assessed in light of a new "cost-reasonableness" test, which involves a comparison of the cost and level of reduction of conventional pollutants from the discharge of POTWs to the cost and level of reduction of such pollutants from a class or category of industrial sources. As part of its review of BAT for certain "secondary" industries, EPA proposed methodology for this cost test. (See 43 Fed. Reg. 37570, August 23, 1978).

For the steel industry, proposed BCT effluent limitations are based upon performance of treatment technologies that remove conventional pollutants. These technologies are compatible with BAT treatment models for each subcategory. Hence, in no instance are proposed BCT and BAT limitations incompatible from a technical or engineering viewpoint. In the event the BCT cost test fails, the propose BCT limitations are based upon the proposed BPT limitations. In no case are proposed BCT limitations less stringent than proposed BPT limitations.

BCT Cost Test

The criteria for the BCT Cost Test are contained in Section 304(b)(4)(B) of the Clean Water Act, which requires a consideration of the "cost reasonableness" of effluent limitations for conventional pollutants. The BCT Cost Test comparison is done between the cost and level of reduction of the conventional pollutants at a publicly owned treatment works and the cost and level of reduction of such pollutants in the appropriate iron and steel subcategory.

For the steel industry, the BCT Cost Test was completed using the methodology outlined in the August 29, 1979 Federal Register. Basically, the test considers the incremental annual cost from BPT to BAT and the conventional pollutant load removal from BPT to BAT.

The results of the BCT Cost Test for the BCT Alternatives are presented in Table X-1.

The costs on a dollar per pound basis as determined above were compared with $1.34/lb (July 1978 dollars) determined for POTWs (See Federal Register, August 29,1979, pp. 50732-50763. Seven of the twelve steel industry subcategories had BCT costs equal to or less than $1.34/lb. In these subcategories, BCT limitations are being proposed which are based on the selected BCT Alternative noted in the last column of Table X-1. As noted above, BCT limitations are being proposed at the BPT level for other subcategories. The BCT limitations being proposed are listed in Table I-5. For additional details on model BCT treatment systems, reference is made to the respective subcategory reports.

Since the BCT alternatives are compatible with the proposed BAT systems discussed in Section IX, the costs for these systems are included in the cost analysis for BAT. The BCT costs for the respective subcategories are listed in Table IX-3.

TABLE X-1

RESULTS OF THE BCT COST TEST
IRON AND STEEL INDUSTRY
(COST TEST OBJECTIVE: $1.34/lb of BCT POLLUTANT REMOVED OR LESS(1))

	$/lb of Conventional Pollutants Removed(2)			
Subcategory	BCT-1	BCT-2	BCT-3	BCT Alt. Selected
A. Cokemaking				
1. By-Product	0.81	0.81	0.46	BCT-1
2. Beehive	-	-	-	BPT
B. Sintering	0.60	1.30	-	BCT-2
C. Ironmaking	0.35	0.63	1.08	BCT-3
D. Steelmaking				
1. BOF: w/sc	0.53	1.54	-	BCT-1
: w/oc	1.16	2.18	-	BCT-1
2. OH - Wet	0.71	1.61	-	BCT-1
3. EF - Wet	1.95	3.72	-	BPT
E. Vacuum Degassing	1.85	-	-	BPT
F. Continuous Casting	0.48	-	-	BCT-1
G. Hot Forming				
1. Primary	0.65	0.65	-	BCT-1
2. Section	0.54	0.54	-	BCT-1
3. Flat				
a. HS&S	0.46	0.46	-	BCT-1
b. Carbon Plate	0.63	0.63	-	BCT-1
c. Spec. Plate	0.94	0.94	-	BCT-1
4. Pipe & Tube	0.89	0.89	-	BCT-1

TABLE X-1
RESULTS OF THE BCT COST TEST
IRON AND STEEL INDUSTRY
PAGE 2

Subcategory	\$/lb of Conventional Pollutants Removed(2) BCT-1	BCT-2	BCT Alt. Selected
H. Scale Removal			
1. Kolene	12.03	-	BPT
2. Hydride	1.32	-	BCT-1
I. Acid Pickling			
1. Sulfuric			
a. Batch Neut.	1.74	2.66	BPT
b. Cont. Neut.	2.07	2.45	BPT
2. Hydrochloric			
a. Cont. Regen.	0.61	0.76	BCT-2
b. Batch Neut.	3.60	5.28	BPT
c. Cont. Neut.	0.72	0.88	BCT-2
3. Combination			
a. Batch	2.43	4.00	BPT
b. Continuous	1.54	2.10	BPT
J. Cold Forming			
1. Cold Rolling			
a. Recirculated	12.82	12.82	BPT
b. Combination	0.91	0.91	BCT-1
c. Direct Appl.	0.46	0.46	BCT-1
2. Pipe & Tube	-	-	BPT
K. Alkaline Cleaning			
a. Batch	18.30	-	BPT
b. Continuous	4.20	-	BPT

TABLE X-1
RESULTS OF THE BCT COST TEST
IRON AND STEEL INDUSTRY
PAGE 3

Subcategory	$/lb of Conventional Pollutants Removed[2] BCT-1	BCT-2	BCT Alt. Selected
L. Hot Coating			
1. Galvanizing			
a. s/s w/s	0.58	0.75	BCT-2
b. s/s wo/s	0.99	1.27	BCT-2
c. Wire w/s	0.53	0.87	BCT-2
d. Wire wo/s	0.57	1.10	BCT-2
2. Terne			
a. w/scrubbers	0.87	1.15	BCT-2
b. wo/scrubbers	1.36	1.82	BPT
3. Other Metals			
a. s/s w/s	0.75	1.02	BCT-2
b. s/s wo/s	1.20	1.66	BCT-1
c. Wire w/s	1.54	2.88	BPT
d. Wire wo/s	1.21	3.31	BCT-1

---

(1) Adjusting the $1.15/lb figure (43 Fed. Reg. 37570, August 23, 1978) to 7/1/78 dollars.

(2) TSS plus oil and grease.

VOLUME I

SECTION XI

EFFLUENT QUALITY ATTAINABLE THROUGH THE APPLICATION OF NEW SOURCE PERFORMANCE STANDARDS

Introduction

The effluent limitations which must be achieved by new sources, i.e., any source, the construction of which is started after publication of New Source Performance Standard (NSPS) regulations, are to specify the degree of effluent reduction achievable through the application of the best available demonstrated control technology, processes, operating methods, or other alternatives, including, where applicable, a standard requiring no discharge of pollutants.

For new source plants, a "no-aqueous discharge of pollutants" limit was sought for each subcategory. There were numerous facilities in some subcategories that demonstrate zero discharge. However, for many of these subcategories a zero discharge may not be attainable for all new sources. In these situations treatment systems at lowest achievable flow rates have been considered.

Because new plants can be designed with water conservation and innovative technology in mind, costs can be minimized by treating the lowest possible wastewater flows. No considerations had to be given to the "add-on" approach that was characteristic of the BPT and BAT systems and therefore the NSPS Alternatives consider the most efficient treatment components and systems. NSPS systems are similar to the BAT systems; however, in some subcategories, alternate treatment components are included which are less costly.

Several alternative treatment systems were considered, but for various reasons, all could not be used as the basis for NSPS Alternatives. One of these systems was cascade water usage across operations. New steelmaking installations have a greater opportunity to cascade process waters from one steelmaking or finishing operation to another starting with the operation with the most stringent water quality requirements and progressing to the operation with the lowest quality requirements. In this way, both the intake and discharge flow requirements are reduced. Because new mills can be designed with this approach in mind, areas where cascade water usage is possible can be located in close proximity to reduce pumping costs. Also, systems with compatible wastewaters can be centrally located to share treatment systems or other disposal practices. Unfortunately, such reuse systems could not be considered for NSPS. When developing the limitations and standards for the steel industry, it was necessary to consider each steelmaking/finishing operation as standing alone thus allowing for "worst case" cost estimates. Hence, cost savings associated with a greenfield plant are not acknowledged in the estimates. Neither are savings associated with using existing treatment facilities at large plants where only one new source is added.

Identification of NSPS

The alternative treatment systems considered for NSPS are similar to the alternatives considered for BAT with minor exceptions. However, as noted above, in many subcategories lower discharge flows are considered for NSPS. Since the criteria for NSPS is to consider only the very best systems, the lowest demonstrated flow could be used to develop NSPS standards. Table XI-1 lists the treatment systems used as models for NSPS. The standards derived from the use of the technologies are listed in the individual subcategory reports.

NSPS Costs

As part of this study, the Agency did not estimate the number of new source plants to be built in the future. However, the Agency did consider the potential economic impacts of NSPS in Economic Analysis of Proposed Effluent Guidelines - Integrated Iron and Steel Industry. Model costs for the NSPS systems are detailed in the individual subcategory reports.

VOLUME I

SECTION XII

PRETREATMENT STANDARDS FOR PLANTS DISCHARGING TO PUBLICLY OWNED TREATMENT WORKS

Introduction

The industry discharges untreated or partially treated wastewaters to publicly owned treatment works (POTWs) from operations in each subcategory. Table XII-1 lists all plants which reported in the DCPs discharges to a POTW. In the individual subcategory reports, two classes of discharges to POTWs were addressed: existing sources and new sources. Also, the national pretreatment standards developed for indirect discharges fall into two separate groups: prohibited discharges, covering all POTW users, and categorical standards applying to specific industrial subcategories.

As was done for BAT, BCT and NSPS, various alternative treatment systems were considered for Pretreatment standards. Up to four alternatives have been considered for each subcategory. To develop the Pretreatment Alternatives, four main factors were considered:

1. Wastewaters should be sufficiently treated to eliminate shock loads.
2. Toxic pollutants should be reduced or eliminated so that the biological activity in the POTW system is not impaired.
3. Toxic and nonconventional pollutants should be reduced or eliminated so they will not pass through POTWs that are not designed to remove these pollutants.
4. Toxic pollutants should be reduced or eliminated in the industrial discharge, so that they will not accumulate in POTW sludges, which could restrict the sludge from being used or from being properly disposed.

National Pretreatment Standards

EPA has developed national standards that apply to all POTW discharges. For detailed information on the Agency's approach to Pretreatment Standards refer to 43 FR 27736-27773, "General Pretreatment Regulations for Existing and New Sources of Pollution, Monday, June 16, 1978." In particular, Part 403, Section 403.5 *et. seq.* describes national standards, prohibited discharges and categorical standards, POTW pretreatment programs, and a national pretreatment strategy.

Prohibited Discharges - Existing and New Sources

Prohibited discharges to POTWs from any source include:

1. Pollutants which create a fire or explosion hazard in POTWs.
2. Pollutants which cause corrosive structural damage to the POTW unless the POTW is specifically designed to handle corrosive discharges.
3. Solid and viscous pollutants which obstruct flow in sewers or otherwise interfere with POTW operations.
4. Any pollutant, including oxygen demanding pollutants, in such volumes or strengths as to cause interference in POTW operations.
5. Heat in amounts which inhibit biological activity in the POTW. In no case can the temperature at the influent to the POTW exceed 40°C (104°F) unless the POTW is specifically designed to handle such heated discharges.

Potential Impacts of Steel Industry Wastes on POTW Systems

As noted previously, many of the wastewaters generated in the steel industry contain toxic metals and organics in significant amounts. The proposed pretreatment Standards for the steel industry limit the discharge of these toxic pollutants because high concentrations of toxic metals and organics can affect the POTW in the following ways:

1. Inhibition of or interference with the POTW treatment process
2. Pass-through during POTW treatment
3. Contamination of POTW sludges

Various studies[15] have demonstrated that toxic pollutants found in steel industry wastewaters can and do inhibit POTW biological treatment processes at levels which exist in steel industry wastewaters. The concentration of toxic pollutants in steel industry effluent is an important factor since many POTWs treat relatively high industrial flows in relation to sanitary wastes. As part of this study, it was not feasible for the Agency to evaluate each POTW receiving other industrial wastes as well as steel industry wastes to determine a safe dilution ratio for steel industry wastes on a subcategory or industry-wide basis. Hence, the Agency's approach is to propose pretreatment standards for each subcategory to a level such that interference with POTW operations, pass through of toxic pollutants, and contamination of POTW sludges is kept to a minimum. In most instances, the proposed pretreatment standards are based upon the proposed BAT and NSPS limitations and standards, conventional pollutants excluded. Some of the toxic pollutants are listed below together with their inhibitory concentrations in activated sludge systems.

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[15] EPA-430/9-76-017a, Construction Grants Program Information; Federal Guidelines, State and Local Pretreatment Programs.

Pollutant	Inhibitory Concentration (mg/l)
Arsenic	0.1
Chromium, hexavalent	1-10
Copper	1.0
Cyanide	0.1-5
Lead	0.1
Zinc	0.08-10

The treatment components used for the pretreatment systems are designed to reduce the concentrations of these, and other pollutants, that may inhibit the treatment efficiency of POTW systems.

Other studies[16] involving the electroplating industry indicated that from 50 to 90 percent of the toxic metals in the influent to a POTW treatment system will pass through the treatment system. With high industrial loads, it is likely that POTWs could discharge environmentally detrimental levels of toxic metals.

Toxic metals which do not pass through a POTW are not destroyed by the biological treatment; and, as a result, these metals concentrate in the POTW sludges. Generally, land application is the least expensive and yet most advantageous method of POTW sludge disposal. A primary advantage derived from the land application of POTW sludges is the addition of essential soil nutrients from the sludges, thus serving as a fertilizer. Excessive amounts of toxic metals in the sludges can, however, inhibit plant growth, thus making these sludges unacceptable for use as a soil nutrient. Also, these toxic metals can enter either the plant and animal food chain or ground waters, and eventually enter water supplies. Both of these situations are environmentally unacceptable. For the above reasons, the control of the toxic pollutants in the steel industry discharges to POTWs is necessary.

Pretreatment Standards for Existing Sources (PSES)

Plants in all twelve subcategories discharge wastewaters to POTW systems. As noted above, to control the discharge of potentially harmful pollutants and flow, Pretreatment Standards for Existing Sources (PSES) have been developed based primarily on the selected BAT technologies. The limitations and costs are essentially the same as were reviewed in Section IX of this report. Additional details on Pretreatment Standards for Existing Sources are presented in the respective subcategory reports.

Pretreatment Standards for New Sources (PSNS)

The pretreatment standards being proposed for new source plants discharging to POTWs are identical to the NSPS requirements for direct dischargers. For the appropriate NSPS standards and costs for these NSPS systems, the respective subcategory reports should be consulted.

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[16] Refer to Federal Register; Friday, September 7, 1979; Part IV, Environmental Protection Agency; Effluent Guidelines and Standards; Electroplating Point Source Category; Pretreatment Standards for Existing Sources - Pages 52597-52601.

TABLE XII-1
POTW DISCHARGERS

PLANT	BY-PRODUCT COKEMAKING	BEEHIVE COKEMAKING	SINTERING	BLAST FURNACE	B.O.F.	OPEN HEARTH	ELECTRIC FURNACE	VACUUM DEGASSING	CONTINUOUS CASTING	HOT FORMING-PRIMARY	HOT FORMING-SECTION	HOT FORMING-FLAT	PIPE AND TUBE	SULFURIC ACID PICKLING	HYDROCHLORIC ACID PICKLING	COLD ROLLING	HOT COATING (GALV. AND OTHER METALS)	HOT COATING-TERNE	COMBINATION ACID PICKLING	SCALE REMOVAL	ALKALINE CLEANING	PRETREATMENT PRIOR TO POTW DISCHARGE	JOINT PRETREATMENT (TWO OR MORE SUBCATEGORIES) PRIOR TO POTW DISCHARGE
0020B																X						X	
0020C																X						X	
0024A	X																					X	
0046D														X									
0060	X																					X	
0060D																X						X	
0060E																X							
0060G														X			X					X	X
0060I																			X			X	
0060L															X								
0060M														X									
0060R																	X						
0060S														X			X					X	X
0068										X	X			X	X		X		X		X		
0068B														X									
0068C																					X		
0112A	X																					X	
0112F														X			X					X	X
0112G														X			X						
0136B											X												
0136C											X											X	
0176C													X						X			X	X
0176D													X						X			X	
0180									X													X	
0212	X																					X	
0248A	X																					X	
0248E																			X				
0256A														X									
0256M																			X	X	X	X	X
0264														X			X						
0264A																	X						
0264C														X									
0264D														X			X						
0280B	X																					X	
0284A									X													X	
0320	X																						
0360	X																					X	
0384A	X															X						X	
0396A	X		X	X																		X	X
0396C	X																					X	
0396D										X		X			X	X						X	X
0432B																X	X					X	
0432E														X			X		X				
0432J										X	X											X	X
0432L																			X				
0440A											X								X	X		X	X
0444									X													X	
0448A												X			X	X	X			X		X	X
0460B											X											X	
0460C														X			X						
0460F														X			X					X	X
0460G														X			X					X	X
0460H														X			X				X	X	X
0464B	X																					X	
0464C	X																					X	
0528																				X	X	X	X
0548B														X		X			X		X	X	X
0580														X	X				X		X		
0580B															X						X		
0580C														X	X	X						X	X
0580E															X								
0580F															X								
0580G																	X		X		X		
0584H													X									X	
0636														X					X		X	X	X
0640																	X						
0640A											X											X	
0640B																	X		X			X	X
0648																X		X	X			X	X
0656A	X																					X	
0672B										X													
0684H	X			X	X																	X	X
0684K														X					X				
0684Z																					X		
0686A									X														
0740A									X														
0760														X							X		
0776C																			X		X	X	X
0776D														X							X		
0792A																	X		X				
0792C														X									
0810	X																					X	
0856S														X	X		X					X	X
0860B	X																					X	
0860G														X									
0860H										X	X	X										X	X
0884E													X						X			X	
0946A	X				X						X											X	
0946C	X																					X	
TOTAL (89 Sites)	19	0	1	2	2	0	0	0	5	5	9	3	4	27	10	11	21	1	19	4	14	53	23

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SECTION XIII

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VOLUME I

APPENDIX A

STATISTICAL METHODOLOGY AND DATA ANALYSIS

Introduction

Statistical Methodology

This section provides an overview of the statistical methodology employed to determine effluent guidelines limitations for the steel industry. The methodology consists essentially of determining long term average pollutant discharges expected from a well designed and operated treatment system, and multiplying these long term averages by variability factors designed to allow for random fluctuations in treatment system performance. The resulting products yield daily maximum and monthly average concentrations for each pollutant. The daily maximum and monthly average concentrations were then multipled by an appropriate conversion factor and the respective treatment system effluent flow to determine mass limitations. A general description of the methods employed to derive long term averages, variability factors, and the resulting concentrations follows.

Determination of Long Term Average

For each plant, an average pollutant concentration was calculated from the daily observations. The median of the plant averages for a pollutant was then used as the long term average for the industry. The long term average was determined for each pollutant to be regulated, and used to obtain corresponding limitations for that pollutant.

The long term average (LTA) is defined as the expected discharge concentration of a pollutant in mg/l from a steel plant having a well designed, maintained, and operated treatment system. It is not a limitation, but rather as a design value which the treatment system should be designed to attain over the long term.

Determination of Variability Factors

Even plants that are achieving good pollutant removals experience fluctuations in the pollutant concentrations discharged. These fluctuations may reflect temporary imbalances in the treat- ment system caused by fluctuations in flow, raw waste load of a particular pollutant, chemical feed, mixing flows within tanks, or a variety of other factors.

Allowance for the day-to-day variability in the concentration of a pollutant discharged from a well designed and operated treat- ment system is incorporated into the standards by the use of a "variability factor." Under certain assumptions, discussed below, application of a variability factor allows the calculation of an upper bound for the concentration of a particular pollutant. On the average a specified percent of the randomly observed daily values from treatment systems discharging this pollutant at a known mean concentration would be expected to fall below this bound. A 99 percentile for the daily maximum value is a commonly used and accepted level in the steel and other industrial categories. Also, this percentile has been chosen to provide a balance between appropriate considerations of day-to-day variation in a properly operating plant and the necessity to insure that a plant is operating properly.

The derivation of the variability factor for plants with more than 10 but less than 100 observations is based on the assumption that the daily pollutant concentrations follow a lognormal distribution. This assumption is supported by plots of the empirical distribution function of observed concentrations for various pollutants (Figures A-1 to A-4). The plots of these data on lognormal probability paper approximated straight lines as would be expected of data that is lognormally distributed. It is also assumed that monitoring at a given plant was conducted responsibly and in such a way that resulting measurements can be considered independent and amenable to standard statistical procedures. A final assumption is that treatment facilities and monitoring techniques had remained substantially constant throughout the monitoring period.

The daily maximum variability factor is estimated by the equation (derived in Appendix XII-A1 of the Development Document for Electroplating Pretreatment Standards, EPA 440/1-79/003, August, 1979),

$$\ln(\mathrm{VF}) = Z(\mathrm{Sigma}) - .5(\mathrm{Sigma})^2 \qquad (1)$$

where

VF is the variability factor

Z is 2.336, which is the 99 percentile for the standard normal distribution, and

Sigma is the standard deviation of the natural logarithm of the concentrations.

For plants with 100 or more observations for a pollutant, there are enough data to use nonparametric statistics to calculate the daily maximum variability factor. For these cases, the variability factor was calculated by dividing the empirical 99 percentile by the pollutant average. The empirical 99 percentile is that observation whose percentile is nearest 0.99.

The estimated single-day variability factor for each pollutant discharged from a well designed and operated plant was calculated in the following manner:

1. For each plant with 10 or more but less than 100 observations, Sigma was calculated according to the standard statistical

formula[17] and was then substituted into Equation (1) to find the VF.

2. For those plants with over 100 observations, the VF was estimated directly by dividing the 99th percentile of the observed sample values by their average.

3. The median of the plant variability factors was then calculated for each pollutant.

The variability factor for the average of a random sample of 30 daily observations about the mean value of a pollutant discharged from a well designed and operated treatment system was obtained by use of the Central Limit Theorem. This theorem states that the average of a sifficiently large sample of independent and identically distributed observations from any of a large class of population distributions will be approximately normally distributed. This approximation improves as the size of the sample, n, increases. It is generally accepted that a sample size of 25 or 30 is sufficient for the normal distribution to adequately approximate the distribution of the sample average. For many populations, sample sizes as small as 10 or 15 are sufficient.

The monthly variability factor, VF*, allows the calculation of an upper bound for the concentration of a particular pollutant. Under the same assumptions stated above, it would be expected that 95 percent of the randomly observed monthly average values from a treatment system discharging the pollutant at a known mean concentration will fall below this bound. Thus, a well operated plant would be expected, on the average, to incur approximately one violation of the monthly average limitation during a 20 month period. The 95 percentile was chosen in a manner analogous to that explained previously in the discussion of the daily variability factor.

The monthly average variability factor was estimated by the following equation (based on the Central Limit Theorem and previous assumptions),

$$(VF^*) = 1.0 + Z\,(S^*/A) \qquad (2)$$

where

VF* is the monthly average variability factor;

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[17] $\left(\frac{\Sigma(xi - x)^2}{n-1}\right)^{\frac{1}{2}}$

where

$\underline{x}i$ is the ln of observation i
$\bar{x}$ is the average of observations
n is the number of observations

Z is 1.64, which is the 95th percentile of the standard normal distribution;

S* is the estimated standard deviation of the monthly average, obtained by dividing the estimated standard deviation of the daily pollutant concentrations by the square root of 30; and,

A is the average pollutant concentration.

Determination of Limitations

Daily maximum and monthly average concentrations (L and L*, respectively) were calculated for each pollutant from the long term average (LTA), the daily variability factor (VF), and the monthly average variability factor (VF*) for that polluant by the following equations:

$$L = VF \times LTA \qquad (3)$$
$$L^* = VF^* \times LTA \qquad (4)$$

The above concentrations were multiplied by the effluent flow (gal/ton) developed for each treatment subcategory and an appropriate conversion factor to obtain mass limitations in units of kg/1,000 kg of product.

The daily maximum limitation calculated for each pollutant is a value which is not to be exceeded on any one day by a plant discharging that pollutant. The monthly average maximum limitation is a value which is not to be exceeded by the average of 30 consecutive single-day observations for the regulated pollutant.

Analysis of Data From Filtration and Clarification Treatment Systems

The observations used to derive daily maximum and monthly average concentrations include both long term and short term data obtained from the D-DCPs and sampling visits, respectively. Engineering judgment[18] was used to delete some data from the long term data sets analyzed. Generally those data deleted indicate possible upsets, lack of proper operation of treatment facilities, or bypasses. These values typically could be considered effluent violations under the NPDES permit system. The number of observations deleted for each pollutant is identified in Tables A-8 to A-33. A discussion of the analysis for filtration and for clarification treatment systems follows.

Filtration Treatment System

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[18] The Agency's justification for using engineering judgment to delete values from monitoring data sets was upheld in U.S. Steel Corp. v. Train, 556 F.2d 822 (7th Cir. 1977).

Table A-1 presents averages and variability factors for the concentration of total suspended solids for those plants[19] with long term data and filtration treatment systems. Detailed descriptive statistics for all relevant pollutants sampled by these plants are located in Tables A-8 to A-17. The median or long term average is multiplied by the apporpriate median variability factor to obtain the daily maximum and monthly average concentrations for TSS as presented in Table A-1. Table A-2 presents, in a similar manner, averages, variability factors and daily maximum and monthly average concentations for oil and grease.

Long term and short term data were combined in Table A-3 to determine the median or long term average concentation for each toxic metal. Variability factors were calculated for those plants having long term metals data and are presented in Table A-4. The median daily maximum variability factors for the metals range from 2.0 to 4.5 and the 30-day variability factor is 1.2. These values are similar to those obtained for TSS and oil and grease. Therefore, variability factors of 4.0 to 1.2 were used to obtain the daily maximum and monthly average concentrations, respectively. The results are presented in Table A-4. The daily maximum and monthly average concentrations were rounded up to 0.3 and 0.1 mg/l, respectively, for all metals. These values will be used to calculate mass limitations for the metals.

Clarification/Sedimentation Treatment System

Tables A-5 and A-6 present both long term data and the calculations used to derive the daily maximum and monthly average concentrations for TSS and oil and grease, respectively. These results are for plants with clarifcation/sedimentation wastewater treatment systems. Detailed descriptive statistics of these plants are given in Tables A-18 to A-33. For Plants 0112, 0684F, and 0684H, long term data was provided for several parallel treatment systems in one central treatment facility. In these situations the data from the clarifier providing the best treatment were used.

For metals removed by clarification treatment systems, screening and verification data were used to calculate the long term averages. These are presented in Table A-7. Variability factors of 3.0 and 1.2 were used to calculate the daily maximum and monthly average concentrations (shown in Table A-7), respectively, for all the metals. The above variability factors were based on:

1. the variability factors for TSS and oil and grease in Tables A-5 and A-6; and,

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[19] Plant 920N was not included in this long term data analysis. Visits to this plant by EPA personnel have demonstrated that the treatment system was not properly operated.

2. the variability factors[20] derived from toxic metals discharged from clarification treatment systems in the electroplating category.

The daily maximum and monthly average concentrations were rounded to 0.3 and 0.1 mg/l, respectively for chromium, copper, lead and zinc and 0.45 and 0.2 mg/l for nickel.

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[20] Daily maximum variability factors presented in the "Development Document for Electro- plating Pretreatment Standards"; are: Cu - 3.2, Cr - 3.9, Ni - 2.9, Zn - 3.0, Pb - 2.9.

TABLE A-1

LONG-TERM DATA ANALYSIS
FILTRATION SYSTEMS
TOTAL SUSPENDED SOLIDS

Plant	Number of Sample Points	Average (mg/1)	Variability Factors Average	Variability Factors Maximum*
0112C-334	415	2.3	1.4	6.8
0112I-5A	59	3.6	1.5	8.9
0112C-617	399	4.8	1.3	5.4
0684H-EF	40	6.0	1.3	5.3
0112C-011	580	8.9	1.3	3.5
0112B-5A	87	10.6	1.1	2.3
0384A-4L	289	12.4	1.2	3.8
0112C-122	496	13.3	1.3	4.0
0384A-3E	305	17.4	1.2	2.5
0684F-4I	78	22.2	1.2	3.7
Median Values		9.8	1.3	3.9

Monthly Average Concentration Basis = (9.8 mg/1) (1.3) = 12.7 mg/1

Daily Maximum Concentration Basis = (9.8 mg/1) (3.9) = 38.2 mg/1

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* For plants with more than 100 observations:

$$\text{Daily Variability Factor} = \frac{\text{99th Percentile}}{\text{Average}}$$

TABLE A-2

LONG-TERM DATA ANALYSIS
FILTRATION SYSTEMS
OIL AND GREASE

Plant	Number of Sample Points	Average (mg/1)	Variability Factors Average	Variability Factors Maximum*
0112B-5A	87	1.1	1.1	2.9
0112C-334	727	1.3	1.4	5.3
0112C-617	647	1.3	1.4	4.5
0112C-122	684	2.0	1.3	5.3
0684H-EF	27	3.4	1.4	3.8
0112C-011	690	6.7	1.3	5.1
0384A-4L	290	7.4	1.3	3.6
0684F-4I	79	9.6	1.1	2.3
Median Values		2.7	1.3	4.2

Monthly Average Concentration Basis = (2.7 mg/1) (1.3) = 3.5 mg/1

Daily Maximum Concentration Basis = (2.7 mg/1) (4.2) = 11.3 mg/1

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* For plants with more than 100 observations:

$$\text{Daily Variability Factor} = \frac{\text{99th Percentile}}{\text{Average}}$$

TABLE A-3

DATA ANALYSIS
FILTRATION SYSTEMS
REGULATED METALLIC POLLUTANTS

Plant	Number of Sample Points	Average (mg/l)
A. Chromium		
0112I-5A	61	0.02
0684F-4I	11	0.03
0684H	3	0.03
0584E	3	0.03
0496	3	0.03
0612	3	0.04
MEDIAN		0.03
B. Copper		
0584F	3	0.015
0684F-4I	11	0.02
0684H	3	0.02
0612	3	0.03
0496	3	0.05
0112I-5A	60	0.05
0868B	3	0.25
MEDIAN		0.03
C. Lead		
0684F-4I	11	0.03
0684H	3	0.05
0496	3	0.05
0112I	3	0.07
0612	3	0.18
0868B	3	0.32
MEDIAN		0.06

TABLE A-3
DATA ANALYSIS
FILTRATION SYSTEMS
REGULATED METALLIC POLLUTANTS
PAGE 2

Plant	Number of Sample Points	Average (mg/1)
D. Nickel		
0684H	3	0.02
0612	3	0.025
0496	3	0.04
0112I-5A	27	0.07
0684F-4I	11	0.09
MEDIAN		0.04
E. Zinc		
0684H	3	0.02
0584E	3	0.02
0496	3	0.02
0112I-5A	58	0.10
0612	3	0.12
0684F	45	0.39
0868B	3	1.6
MEDIAN		0.10

TABLE A-4

DERIVATION OF VARIABILITY FACTORS AND PROPOSED LIMITS
FILTRATION SYSTEMS
REGULATED METALLIC POLLUTANTS

Derivation of Variability Factors

Parameter	No. of Sample Points	Variability Factors	
		Average	Maximum
A. Chromium			
0112I-5A	61	1.2	2.9
0684F-4I	11	1.2	3.6
MEDIAN		1.2	3.3
B. Copper			
0112I-5A	60	1.2	5.1
0684F-4I	11	1.1	2.7
MEDIAN		1.2	3.9
C. Lead			
0684F-4I	11	1.1	2.0
D. Nickel			
0112I-5A	27	1.2	3.3
0684F-4I	11	1.2	5.6
MEDIAN		1.2	4.5
E. Zinc			
0112I-5A	58	1.2	3.0
0684F-4I	45	1.2	4.2
MEDIAN		1.2	3.6

NOTE: Use for all regulated metals
Average Variability Factor = 1.3
Maximum Variability Factor = 4.0

TABLE A-4
DERIVATION OF VARIABILITY FACTORS AND PROPOSED LIMITS
FILTRATION SYSTEMS
REGULATED METALLIC POLLUTANTS
PAGE 2

Derivation of Concentration Values

A. Chromium

Monthly Average Concentration Basis = (0.03)(1.3) = 0.04
Daily Maximum Concentration Basis = (0.03)(4.0) = 0.12

B. Copper

Monthly Average Concentration Basis = (0.03)(1.3) = 0.04
Daily Maximum Concentration Basis = (0.03)(4.0) = 0.12

C. Lead

Monthly Average Concentration Basis = (0.06)(1.3) = 0.08
Daily Maximum Concentration Basis = (0.06)(4.0) = 0.24

D Nickel

Monthly Average Concentration Basis = (0.04)(1.3) = 0.05
Daily Maximum Concentration Basis = (0.04)(4.0) = 0.16

E. Zinc

Monthly Average Concentration Basis = (0.10)(1.3) = 0.13
Daily Maximum Concentration Basis = (0.10)(4.0) = 0.40

NOTE: For the purposes of developing effluent limitations and standards, the following values were used for all metals:

Average = 0.10 mg/l
Maximum = 0.30 mg/l

All concentration values are in mg/l.

TABLE A-5

LONG-TERM DATA ANALYSIS
CLARIFICATION/SEDIMENTATION SYSTEMS
TOTAL SUSPENDED SOLIDS

Plant	Number of Sample Points	Average (mg/1)	Variability Factors Average	Variability Factors Maximum*
0860B	102	8.9	1.1	2.3
0112-5B	291	9.9	1.3	4.0
0112H-5A	49	11.7	1.2	3.2
0320-5A	151	15.8	1.2	2.3
0384A-5F	97	16.1	1.1	2.8
0684H-5C	74	19.0	1.2	5.4
0684F-5B	380	24.5	1.1	2.4
0584B-5F	98	24.6	1.1	2.3
0920G-5A	195	25.0	1.2	3.1
0584A-5F	101	25.4	1.1	1.8
0384A-5E	383	26.7	1.2	2.5
0856N-5B	101	32.1	1.2	3.2
0112A-5A	175	35.7	1.2	2.5
0684F-5E	528	45.5	1.0	3.6
Median Values		24.6	1.2	2.7

Monthly Average Concentration Basis = (24.6 mg/1) (1.2) = 29.5 mg/1

Daily Maximum Concentration Basis = (24.6 mg/1) (2.7) = 66.4 mg/1

---

*: For plants with more than 100 observations:

$$\text{Daily Variability Factor} = \frac{\text{99th Percentile}}{\text{Average}}$$

TABLE A-6

CLARIFICATION/OIL SKIMMING SYSTEMS
OIL AND GREASE

Plant	Number of Sample Points	Average (mg/l)	Variability Factors	
			Average	Maximum*
0320-5A	35	0.1	1.2	4.0
0584A-5F	98	5.9	1.2	6.7
0856N-5B	103	7.0	1.1	2.0
0584B-5F	58	8.4	1.2	2.9
MEDIAN VALUES		6.5	1.2	3.5

Monthly Average Concentration Basis = (6.5 mg/l)(1.2) = 7.8 mg/l
Daily Maximum Concentration Basis = (6.5 mg/l)(3.5) = 22.8 mg/l

---

* For plants with more than 100 observations:

$$\text{Daily Variability Factor} = \frac{\text{99th Percentile}}{\text{Average}}$$

TABLE A-7

DATA ANALYSIS
CLARIFICATION/SEDIMENTATION SYSTEMS
REGULATED METALLIC POLLUTANTS

Plant	Subcategory	Number of Sample Points	Average (mg/1)
A. Chromium			
0948C	Pickling	3	0.02
NN-2	Galvanizing	3	0.03
0476A	Pickling	3	0.03
0528	Pickling	3	0.03
0396A	Pickling	3	0.08
0920E	Galvanizing	3	0.27
0424-01	Pickling	3	1.32
MEDIAN			0.03

Monthly Average Concentration Basis = (0.03 mg/1)(1.2) = 0.04 mg/1
Daily Maximum Concentration Basis = (0.03 mg/1)(3.0) = 0.09 mg/1

Plant	Subcategory	Number of Sample Points	Average (mg/1)
B. Copper			
0948C	Pickling	3	0.02
0476A	Pickling	3	0.03
0528	Pickling	3	0.03
0920E	Galvanizing	3	0.04
0424-01	Pickling	3	0.08
0396A	Pickling	3	0.17
MEDIAN			0.04

Monthly Average Concentration Basis = (0.04 mg/1)(1.2) = 0.05 mg/1
Daily Maximum Concentration Basis = (0.04 mg/1)(3.0) = 0.12 mg/1

Plant	Subcategory	Number of Sample Points	Average (mg/1)
C. Lead			
0948C	Pickling	3	0.05
0476A	Pickling	3	0.10
0528	Pickling	3	0.10
0396A	Pickling	3	0.57
0920E	Galvanizing	3	0.60
MEDIAN			0.10

Monthly Average Concentration Basis = (0.10 mg/1)(1.2) = 0.12 mg/1
Daily Maximum Concentration Basis = (0.10 mg/1)(3.0) = 0.30 mg/1

TABLE A-7
DATA ANALYSIS
CLARIFICATION/SEDIMENTATION SYSTEMS
REGULATED METALLIC POLLUTANTS
PAGE 2

Plant	Subcategory	Number of Sample Points	Average mg/1
D. Nickel			
0948C	Pickling	3	0.03
0476A	Pickling	3	0.03
0528	Pickling	3	0.03
0396A	Pickling	3	0.27
0424-01	Pickling	3	2.50
0920E	Galvanizing	3	2.90
MEDIAN			0.15

Monthly Average Concentration Basis = (0.15 mg/1)(1.2) = 0.18 mg/1
Daily Maximum Concentration Basis = (0.15 mg/1)(3.0) = 0.45 mg/1

Plant	Subcategory	Number of Sample Points	Average mg/1
E. Zinc			
0528	Pickling	3	0.02
0424-01	Pickling	3	0.035
0476A	Pickling	3	0.05
0948C	Pickling	3	0.07
0396A	Pickling	3	0.24
0920E	Galvanizing	3	6.7
MEDIAN			0.06

Monthly Average Concentration Basis = (0.06 mg/1)(1.2) = 0.07 mg/1
Daily Maximum Concentration Basis = (0.06 mg/1)(3.0) = 0.18 mg/1

NOTE: For the purposes of developing effluent limitations and standards, the following values were used:

For chromium, copper lead and zinc - Average = 0.10 mg/1
Maximum = 0.30 mg/1

For nickel - Average = 0.20 mg/1
Maximum = 0.45 mg/1

TABLE A-8

LONG-TERM DATA ANALYSIS

Plant : 0112B-5A
Subcategory: Hot Forming
Treatment : Filtration

	Daily Maximum Analysis						Monthly Average Analysis	
Pollutant	No. of Obs	Min	Max	Ave	S_d	VF_d*	S_m	VF_m
TSS	87	1.6	24.4	10.6	3.9	2.3	0.7	1.1
Oil & Grease	87	0.2	3.8	1.1	0.6	2.9	0.1	1.1

S_m : Monthly standard deviation = $S_d/(30)^{.5}$
S_d : Daily standard deviation
VF_m: Monthly variability factor
VF_d: Daily variability factor

* : For plants with more than 100 observations: $VF_d = \frac{\text{99th Percentile}}{\text{Average}}$

TABLE A-9

LONG-TERM DATA ANALYSIS

Plant : 0112C-011
Subcategory: Hot Forming
Treatment : Filtration

Pollutant	Daily Maximum Analysis						Monthly Average Analysis	
	No. of Obs	Min	Max	Ave	S_d	VF_d*	S_m	VF_m
TSS	580(2)	0.1	44.0	8.9	7.0	3.5	1.3	1.3
Oil & Grease	690(1)	0.1	47.1	6.7	6.5	5.1	1.2	1.3

---

(1) 5 observations deleted
(2) 11 observations deleted

S_m : Monthly standard deviation = $S_d/(30)^{.5}$
S_d : Daily standard deviation
VF_m : Monthly variability factor
VF_d: Daily variability factor

* : For plants with more than 100 observations: $VF_d = \frac{\text{99th Percentile}}{\text{Average}}$

TABLE A-10

LONG-TERM DATA ANALYSIS

Plant : 0112C-122
Subcategory: Hot Forming
Treatment : Filtration

	Daily Maximum Analysis						Monthly Average Analysis	
Pollutant	No. of Obs	Min	Max	Ave	S_d	VF_d*	S_m	VF_m
TSS	$496^{(2)}$	0.1	63.4	13.3	12.4	4.0	2.3	1.3
Oil & Grease	$684^{(1)}$	0.1	20.3	2.0	2.2	5.3	0.4	1.3

---

(1) 1 observation deleted
(2) 7 observations deleted

S_m : Monthly standard deviation = $S_d/(30)^{.5}$
S_d : Daily standard deviation
VF_m: Monthly variability factor
VF_d: Daily variability factor

* : For plants with more than 100 observations: $VF_d = \frac{\text{99th Percentile}}{\text{Average}}$

TABLE A-11

LONG-TERM DATA ANALYSIS

Plant : 0112C-334
Subcategory: Hot Forming
Treatment : Filtration

	Daily Maximum Analysis						Monthly Average Analysis	
Pollutant	No. of Obs	Min	Max	Ave	S_d	VF_d*	S_m	VF_m
TSS	415	0.1	23.5	2.3	3.0	6.8	0.5	1.4
Oil & Grease	727	0.1	12.2	1.3	1.4	5.3	0.3	1.4

S_m : Monthly standard deviation = $S_d/(30)^{.5}$
S_d : Daily standard deviation
VF_m: Monthly variability factor
VF_d: Daily variability factor

* : For plants with more than 100 observations: $VF_d = \frac{\text{99th Percentile}}{\text{Average}}$

TABLE A-12

LONG-TERM DATA ANALYSIS

Plant : 0112C-617
Subcategory: Hot Forming
Treatment : Filtration

	Daily Maximum Analysis						Monthly Average Analysis	
Pollutant	No. of Obs	Min	Max	Ave	S_d	VF_d*	S_m	VF_m
TSS	399	0.1	33.8	4.8	5.5	5.4	1.0	1.3
Oil & Grease	647	0.1	7.9	1.3	1.3	4.5	0.3	1.4

S_m : Monthly standard deviation = $S_d/(30)^{.5}$
S_d : Daily standard deviation
VF_m: Monthly variability factor
VF_d: Daily variability factor

* : For plants with more than 100 observations: $VF_d = \frac{\text{99th Percentile}}{\text{Average}}$

TABLE A-13

LONG-TERM DATA ANALYSIS

Plant : 0112I-5A
Subcategory: Pickling/Alkaline Cleaning
Treatment : Filtration

	Daily Maximum Analysis						Monthly Average Analysis	
Pollutant	No. of Obs	Min	Max	Ave	S_d	VF_d*	S_m	VF_m
TSS	59(2)	0.1	30.0	3.6	6.4	8.9	1.2	1.5
Iron	60(1)	0.1	0.9	0.4	0.2	2.6	0.04	1.2
Chromium	61	0.01	0.06	0.02	0.01	2.9	0.002	1.2
Copper	60(1)	0.01	0.2	0.05	0.04	5.1	0.007	1.2
Zinc	58(3)	0.03	0.3	0.1	0.06	3.0	0.01	1.2
Nickel	27	0.02	0.2	0.07	0.04	3.3	0.007	1.2
Aluminum	27	0.2	0.4	0.2	0.03	1.3	0.006	1.0
Phenol	15	0.0005	0.01	0.006	0.003	4.2	0.0005	1.1

---

(1) 1 observation deleted
(2) 2 observations deleted
(3) 3 observations deleted

S_m : Monthly standard deviation = $S_d/(30)^{.5}$
S_d : Daily standard deviation
VF_m: Monthly variability factor
VF_d: Daily variability factor

* : For plants with more than 100 observations: $VF_d = \frac{\text{99th Percentile}}{\text{Average}}$

TABLE A-14

LONG-TERM DATA ANALYSIS

Plant : 0384A-3E
Subcategory: Continuous Casting
Treatment : Filtration

	Daily Maximum Analysis						Monthly Average Analysis	
Pollutant	No. of Obs	Min	Max	Ave	S_d	VF_d*	S_m	VF_m
TSS	305$^{(1)}$	1.0	45.0	17.4	9.3	2.5	1.7	1.2

---

(1) 3 observations deleted

S_m : Monthly standard deviation = $S_d/(30)^{.5}$
S_d : Daily standard deviation
VF_m: Monthly variability factor
VF_d: Daily variability factor

* : For plants with more than 100 observations: $VF_d = \frac{\text{99th Percentile}}{\text{Average}}$

TABLE A-15

LONG-TERM DATA ANALYSIS

Plant : 0384A-4L
Subcategory: Continuous Casting
Treatment : Filtration

	Daily Maximum Analysis						Monthly Average Analysis	
Pollutant	No. of Obs	Min	Max	Ave	S_d	VF_d*	S_m	VF_m
TSS	289(2)	1.0	55.0	12.4	9.6	3.8	1.8	1.2
Oil & Grease	290(1)	0.1	30.0	7.4	6.9	3.6	1.3	1.3

---

(1) 3 observations deleted
(2) 4 observations deleted

S_m : Monthly standard deviation = $S_d/(30)^{.5}$
S_d : Daily standard deviation
VF_m: Monthly variability factor
VF_d: Daily variability factor

* : For plants with more than 100 observations: $VF_d = \frac{\text{99th Percentile}}{\text{Average}}$

TABLE A-16

LONG-TERM DATA ANALYSIS

Plant : 0684H-EF
Subcategory: Pipe & Tube
Treatment : Deep Bed Filter

	Daily Maximum Analysis						Monthly Average Analysis	
Pollutant	No. of Obs	Min	Max	Ave	S_d	VF_d*	S_m	VF_m
TSS	$40^{(1)}$	1.0	21.0	6.0	5.5	5.3	1.0	1.3
Oil & Grease	27	1.0	20.0	3.4	4.0	3.8	0.7	1.4

---

(1) 1 observation deleted

S_m : Monthly standard deviation = $S_d/(30)^{.5}$
S_d : Daily standard deviation
VF_m : Monthly variability factor
VF_d: Daily variability factor

* : For plants with more than 100 observations: $VF_d = \frac{\text{99th Percentile}}{\text{Average}}$

TABLE A-17

LONG-TERM DATA ANALYSIS

Plant : 0684F-4I
Subcategory: Hot Forming
Treatment : Lagoon & Filtration

Pollutant	Daily Maximum Analysis						Monthly Average Analysis	
	No. of Obs	Min	Max	Ave	S_d	VF_d*	S_m	VF_m
TSS	78	4.0	60.0	22.2	13.7	3.7	2.5	1.2
Oil & Grease	79(1)	4.0	27.0	9.6	4.3	2.3	0.8	1.1
Ammonia	6(2)	0.1	0.5	0.3	0.2	4.2	0.04	1.2
Cyanide (Total)	6	0.01	0.05	0.02	0.01	3.6	0.002	1.2
Zinc	45(3)	0.03	1.0	0.39	0.23	4.2	0.2	1.2
Chromium	11	0.01	0.09	0.03	0.02	3.6	0.004	1.2
Copper	11	0.01	0.05	0.02	0.01	2.7	0.002	1.1
Nickel	11	0.01	0.2	0.09	0.07	5.6	0.01	1.2

TABLE A-17
LONG-TERM DATA ANALYSIS
PAGE 2

Plant : 0684F-4I
Subcategory: Hot Forming
Treatment : Lagoon & Filtration

Pollutant	Daily Maximum Analysis No. of Obs	Min	Max	Ave	S_d	VF_d*	Monthly Average Analysis S_m	VF_m
Phenol	6	0.01	0.4	0.1	0.1	9.0	0.02	1.3
Cadmium	11	0.001	0.009	0.004	0.002	3.4	0.0004	1.2
Iron	9	1.6	10.3	5.4	3.3	3.9	0.6	1.2
Zinc (Diss.)	74(3)	0.02	3.4	0.5	0.7	7.2	0.6	1.2
Lead	11	0.02	0.06	0.03	0.01	2.0	0.002	1.1

---

(1) 1 observation deleted
(2) 2 observations deleted
(3) 24 observations deleted**

S_m : Monthly standard deviation = $S_d/(30)^{.5}$
S_d : Daily standard deviation
VF_m: Monthly variability factor
VF_d: Daily variability factor

* : For plants with more than 100 observations: $VF_d = \frac{\text{99th Percentile}}{\text{Average}}$

** : These observations were deleted since the hot forming wastewater treatment system was contaminated with the filtrate from sludges removed from a cold rolling, pickling and galvanizing central treatment system. This filtrate contains high zinc concentrations and resulted in NPDES permit violations for the hot forming discharge.

TABLE A-18

LONG-TERM DATA ANALYSIS

Plant : 0112-5B
Subcategory: Ironmaking
Treatment : Polymer/Clarifier

	Daily Maximum Analysis						Monthly Average Analysis	
Pollutant	No. of Obs	Min	Max	Ave	S_d	VF_d*	S_m	VF_m
TSS	291(1)	1.0	92.4	9.9	9.2	4.0	1.7	1.3

---

(1) 7 observations deleted

S_m : Monthly standard deviation = $S_d/(30)^{.5}$
S_d : Daily standard deviation
VF_m : Monthly variability factor
VF_d: Daily variability factor

* : For plants with more than 100 observations: $VF_d = \frac{\text{99th Percentile}}{\text{Average}}$

TABLE A-19

LONG-TERM DATA ANALYSIS

Plant : 0112A-5A
Subcategory: Sintering
Treatment : Thickener

	Daily Maximum Analysis						Monthly Average Analysis	
Pollutant	No. of Obs	Min	Max	Ave	S_d	VF_d*	S_m	VF_m
TSS	175(2)	10.0	104.0	35.7	19.7	2.5	3.6	1.2
Ammonia	180	18.0	60.0	34.9	6.9	1.6	1.3	1.1
Cyanide (Total)	180	0.005	0.4	0.1	0.08	3.6	0.1	2.6
Phenol	178(1)	0.006	0.4	0.05	0.06	6.2	0.01	1.3

---

(1) 2 observations deleted
(2) 5 observations deleted

S_m : Monthly standard deviation = $S_d/(30)^{.5}$
S_d : Daily standard deviation
VF_m : Monthly variability factor
VF_d: Daily variability factor

* : For plants with more than 100 observations: $VF_d = \frac{\text{99th Percentile}}{\text{Average}}$

TABLE A-20

LONG-TERM DATA ANALYSIS

Plant : 0112H-5A
Subcategory: Combination Acid Pickling
Treatment : Clarifier/Lagoon

Pollutant	Daily Maximum Analysis						Monthly Average Analysis	
	No. of Obs	Min	Max	Ave	S_d	VF_d*	S_m	VF_m
TSS	49	2.8	25.6	11.7	5.9	3.2	1.1	1.2
Iron	$47^{(2)}$	0.01	1.4	0.1	0.2	7.3	0.04	1.8
Zinc	$49^{(1)}$	0.01	1.3	0.2	0.2	11.4	0.04	1.3

---

(1) 1 observation deleted
(2) 2 observations deleted

S_m : Monthly standard deviation = $S_d/(30)^{.5}$
S_d : Daily standard deviation
VF_m: Monthly variability factor
VF_d: Daily variability factor

* : For plants with more than 100 observations: $VF_d = \frac{\text{99th Percentile}}{\text{Average}}$

TABLE A-21

LONG-TERM DATA ANALYSIS

Plant : 0320-5A
Subcategory: Hot Forming
Treatment : Lagoons

	Daily Maximum Analysis						Monthly Average Analysis	
Pollutant	No. of Obs	Min	Max	Ave	S_d	VF_d*	S_m	VF_m
TSS	151(1)	0.1	39.0	15.8	7.4	2.3	1.4	1.2
Oil & Grease	35	0.03	0.3	0.1	0.06	4.0	0.01	1.2
Ammonia	146	0.1	14.0	3.3	2.2	2.7	0.4	1.2

---

(1) 2 observations deleted

S_m : Monthly standard deviation = $S_d/(30)^{.5}$
S_d : Daily standard deviation
VF_m: Monthly variability factor
VF_d: Daily variability factor

* : For plants with more than 100 observations: $VF_d = \frac{\text{99th Percentile}}{\text{Average}}$

TABLE A-22

LONG-TERM DATA ANALYSIS

Plant : 0384A-5E
Subcategory: Ironmaking
Treatment : Thickener

	Daily Maximum Analysis						Monthly Average Analysis	
Pollutant	No. of Obs	Min	Max	Ave	S_d	VF_d*	S_m	VF_m
TSS	383(1)	3.0	74.0	26.7	13.8	2.5	2.5	1.2

---

(1) 4 observations deleted

S_m : Monthly standard deviation = $S_d/(30)^{.5}$
S_d : Daily standard deviation
VF_m: Monthly variability factor
VF_d: Daily variability factor

* : For plants with more than 100 observations: $VF_d = \frac{\text{99th Percentile}}{\text{Average}}$

TABLE A-23

LONG-TERM DATA ANALYSIS

Plant : 0384A-5F
Subcategory: Steelmaking, Basic Oxygen Furnace
Treatment : Thickener/Clarifier

	Daily Maximum Analysis						Monthly Average Analysis	
Pollutant	No. of Obs	Min	Max	Ave	S_d	VF_d*	S_m	VF_m
TSS	97	3.0	47.0	16.1	8.3	2.8	1.5	1.1
Iron	22	2.4	21.0	9.5	4.9	2.8	0.9	1.1

S_m : Monthly standard deviation = $S_d/(30)^{.5}$
S_d : Daily standard deviation
VF_m : Monthly variability factor
VF_d: Daily variability factor

* : For plants with more than 100 observations: $VF_d = \dfrac{\text{99th Percentile}}{\text{Average}}$

TABLE A-24

LONG-TERM DATA ANALYSIS

Plant : 0584A-5F
Subcategory: Hot Forming
Treatment : Settling Basin

	Daily Maximum Analysis						Monthly Average Analysis	
Pollutant	No. of Obs	Min	Max	Ave	S_d	VF_d*	S_m	VF_m
TSS	101(1)	4.0	55.0	25.4	9.1	1.8	1.7	1.1
Oil & Grease	98	0.1	20.6	5.9	4.3	6.7	0.8	1.2

---

(1) 1 observation deleted

S_m : Monthly standard deviation = $S_d/(30)^{.5}$
S_d : Daily standard deviation
VF_m: Monthly variability factor
VF_d: Daily variability factor

* : For plants with more than 100 observations: $VF_d = \frac{\text{99th Percentile}}{\text{Average}}$

TABLE A-25

LONG-TERM DATA ANALYSIS

Plant : 0584B-5F
Subcategory: Hot Forming
Treatment : Lagoons

Pollutant	Daily Maximum Analysis						Monthly Average Analysis	
	No. of Obs	Min	Max	Ave	S_d	VF_d*	S_m	VF_m
TSS	98(1)	10.0	50.0	24.6	8.6	2.3	1.6	1.1
Oil & Grease	58	2.0	29.0	8.4	4.2	2.9	0.8	1.2

---

(1) 3 observations deleted

S_m : Monthly standard deviation = $S_d/(30)^{.5}$
S_d : Daily standard deviation
VF_m: Monthly variability factor
VF_d: Daily variability factor

* : For plants with more than 100 observations: $VF_d = \frac{\text{99th Percentile}}{\text{Average}}$

TABLE A-26

LONG-TERM DATA ANALYSIS

Plant : 0684F-5B
Subcategory: Ironmaking
Treatment : Clarifier

	Daily Maximum Analysis						Monthly Average Analysis	
Pollutant	No. of Obs	Min	Max	Ave	S_d	VF_d*	S_m	VF_m
TSS	380(1)	6.0	64.0	24.5	11.2	2.4	2.0	1.1

---

(1) 1 observation deleted

S_m : Monthly standard deviation = $S_d/(30)^{.5}$
S_d : Daily standard deviation
VF_m : Monthly variability factor
VF_d: Daily variability factor

* : For plants with more than 100 observations: $VF_d = \frac{\text{99th Percentile}}{\text{Average}}$

TABLE A-27

LONG-TERM DATA ANALYSIS

Plant : 0684F-5E
Subcategory: Ironmaking
Treatment : Clarifier

Pollutant	No. of Obs	Daily Maximum Analysis					Monthly Average Analysis	
		Min	Max	Ave	S_d	VF_d*	S_m	VF_m
TSS	$528^{(4)}$	4.0	206.0	45.5	34.4	3.6	0.7	1.0
Oil & Grease	5	2.0	4.0	2.8	1.1	2.3	0.2	1.1
Ammonia	$61^{(2)}$	6.9	67.4	29.5	12.8	2.5	2.3	1.1
Cyanide (Total)	$62^{(1)}$	0.03	1.9	0.5	0.5	8.3	0.09	1.3
Zinc	5	0.1	0.4	0.2	0.1	3.6	0.02	1.2
Chromium	5	0.01	0.05	0.03	0.01	3.2	0.002	1.1
Copper	5	0.02	0.06	0.04	0.02	2.5	0.004	1.2
Nickel	5	0.03	0.08	0.06	0.02	2.1	0.004	1.1
Phenol	$60^{(3)}$	0.01	0.3	0.06	0.04	3.2	0.007	1.2

TABLE A-27
LONG-TERM DATA ANALYSIS
PAGE 2

Plant : 0684F-5E
Subcategory: Ironmaking
Treatment : Clarifier

Pollutant	Daily Maximum Analysis No. of Obs	Min	Max	Ave	S_d	VF_d*	Monthly Average Analysis S_m	VF_m
Cadmium	5	0.006	0.008	0.007	0.0009	1.3	0.0002	1.0
Iron	6	6.2	23.9	14.1	7.4	3.3	1.4	1.2
Lead	5	0.05	0.1	0.08	0.02	2.0	0.004	1.1

---

(1) 2 observations deleted
(2) 3 observations deleted
(3) 5 observations deleted
(4) 11 observations deleted

S_m : Monthly standard deviation = $S_d/(30)^{.5}$
S_d : Daily standard deviation
VF_m : Monthly variability factor
VF_d: Daily variability factor

* : For plants with more than 100 observations: $VF_d = \frac{\text{99th Percentile}}{\text{Average}}$

TABLE A-28

LONG-TERM DATA ANALYSIS

Plant : 0684H-5C
Subcategory: Ironmaking
Treatment : Clarifier

	Daily Maximum Analysis						Monthly Average Analysis	
Pollutant	No. of Obs	Min	Max	Ave	S_d	VF_d*	S_m	VF_m
TSS	74(2)	1.0	64.0	19.0	15.4	5.4	2.8	1.2
Ammonia	73(3)	0.1	36.0	13.4	8.0	5.1	1.5	1.2
Cyanide (Total)	75(1)	0.02	6.98	0.8	1.5	9.8	0.3	1.6
Phenol	72(4)	0.008	4.68	1.6	1.2	8.0	0.2	1.2
Iron (Diss.)	76	0.1	0.6	0.2	0.1	2.8	0.02	1.3

---

(1) 1 observation deleted
(2) 2 observations deleted
(3) 3 observations deleted
(4) 4 observations delted

S_m : Monthly standard deviation = $S_d/(30)^{.5}$
S_d : Daily standard deviation
VF_m : Monthly variability factor
VF_d: Daily variability factor

* : For plants with more than 100 observations: $VF_d = \frac{\text{99th Percentile}}{\text{Average}}$

TABLE A-29

LONG-TERM DATA ANALYSIS

Plant : 0856N-5B
Subcategory: Hot Forming
Treatment : Settling Basin

	Daily Maximum Analysis						Monthly Average Analysis	
Pollutant	No. of Obs	Min	Max	Ave	S_d	VF_d*	S_m	VF_m
TSS	101(2)	9.0	114.0	32.1	21.6	3.2	3.9	1.2
Oil & Grease	103(1)	1.8	20.3	7.0	2.7	2.0	0.5	1.1
Chromium	43(1)	0.005	0.2	0.06	0.05	7.4	0.009	1.2
Zinc	44	0.04	0.5	0.1	0.1	3.4	0.02	1.2

---

(1) 1 observation deleted
(2) 3 observations deleted

S_m : Monthly standard deviation = $S_d/(30)^{.5}$
S_d : Daily standard deviation
VF_m: Monthly variability factor
VF_d: Daily variability factor

* : For plants with more than 100 observations: $VF_d = \frac{\text{99th Percentile}}{\text{Average}}$

TABLE A-30

LONG-TERM DATA ANALYSIS

Plant : 0860B
Subcategory: Ironmaking
Treatment : Clarifier

	Daily Maximum Analysis						Monthly Average Analysis	
Pollutant	No. of Obs	Min	Max	Ave	S_d	VF_d*	S_m	VF_m
TSS	102	1.0	26.0	8.9	4.3	2.3	0.8	1.1
Ammonia (N)	102	4.7	98.1	53.1	15.4	1.7	2.8	1.1
Cyanide (Total)	102	0.01	6.2	1.9	1.6	3.3	0.3	1.3
Phenol	102	0.001	0.6	0.04	0.08	6.8	0.01	1.4
Zinc	18	0.1	0.7	0.4	0.2	4.0	0.04	1.2

S_m : Monthly standard deviation = $S_d/(30)^{.5}$
S_d : Daily standard deviation
VF_m : Monthly variability factor
VF_d: Daily variability factor

* : For plants with more than 100 observations: $VF_d = \frac{\text{99th Percentile}}{\text{Average}}$

TABLE A-31

LONG-TERM DATA ANALYSIS

Plant : 0920G-5A
Subcategory: Cold Rolling
Treatment : Clarifier

Pollutant	Daily Maximum Analysis						Monthly Average Analysis	
	No. of Obs	Min	Max	Ave	S_d	VF_d*	S_m	VF_m
TSS	195	2.0	81.0	25.0	13.3	3.1	2.4	1.2

S_m : Monthly standard deviation = $S_d/(30)^{.5}$
S_d : Daily standard deviation
VF_m: Monthly variability factor
VF_d: Daily variability factor

* : For plants with more than 100 observations: $VF_d = \frac{\text{99th Percentile}}{\text{Average}}$

TABLE A-32

LONG-TERM DATA ANALYSIS

Plant : 0012A-5F
Subcategory: By-product Cokemaking
Treatment : One-stage Biological

Pollutant	Daily Maximum Analysis						Monthly Average Analysis	
	No. of Obs	Min	Max	Ave	S_d	VF_d*	S_m	VF_m
TSS	292(4)	4.0	220.0	81.6	40.7	2.5	7.4	1.2
Oil & Grease	54	4.0	36.0	18.6	8.2	3.0	1.5	1.1
Ammonia (N)	298(2)	14.0	224.0	61.7	41.6	3.4	7.6	1.2
Cyanide (Total)	173(1)	0.5	6.8	2.6	1.4	2.5	0.3	1.2
Phenol	281(3)	0.008	16.2	0.5	1.7	6.4	0.3	2.0

---

(1) 1 observation deleted
(2) 2 observations deleted
(3) 4 observations deleted
(4) 7 observations deleted

S_m : Monthly standard deviation = $S_d/(30)^{.5}$
S_d : Daily standard deviation
VF_m : Monthly variability factor
VF_d: Daily variability factor

* : For plants with more than 100 observations: $VF_d = \frac{\text{99th Percentile}}{\text{Average}}$

TABLE A-33

LONG-TERM DATA ANALYSIS

Plant : 0868A
Subcategory: By-Product Coke
Treatment : 2-stage biological

	Daily Maximum Analysis						Monthly Average Analysis	
Pollutant	No. of Obs	Min	Max	Ave	S_d	VF_d*	S_m	VF_m
TSS	295	16.0	868	162	142	4.5	25.9	1.3
Ammonia-(N)	710	0.1	124.0	9.3	20.5	8.9	3.7	1.7
Cyanide (Total)	710	0.5	6.6	2.1	0.8	2.1	0.1	1.1
Phenol	710	0.009	0.14	0.02	0.014	4.3	0.003	1.2
Naphthalene, ppb	21	10.0	10.0	10.0	0.0	1.0	0.0	1.0
Benzo(a)pyrene, ppb	20	10.0	52.0	13.4	10.7	2.6	2.0	1.2
Benzene, ppb	21	10.0	10.0	10.0	0.0	1.0	0.0	1.0

S_m : Monthly standard deviation = $S_d/(30)^{.5}$
S_d : Daily standard deviation
VF_m: Monthly variability factor
VF_d: Daily variability factor

* : For plants with more than 100 observations: $VF_d = \frac{\text{99th Percentile}}{\text{Average}}$

NOTE: All concentration values are in mg/l unless otherwise noted.

TABLE A-34

LONG-TERM DATA ANALYSIS

Plant : 0860B (Pilot Plant)
Subcategory: Ironmaking
Treatment : Alkaline Chlorination

	Daily Maximum Analysis						Monthly Average Analysis	
Pollutant	No. of Obs	Min	Max	Ave	S_d	VF_d*	S_m	VF_m
TSS	41	1.0	19.0	3.5	3.6	4.8	0.7	1.3
Cyanide (Total)	42	0.01	0.1	0.03	0.03	5.2	0.006	1.5
Ammonia-(N)	42	0.1	2.9	0.7	0.9	8.0	0.2	1.5
Phenol	41	0.001	0.04	0.003	0.006	9.8	0.001	1.4
Fluoride	42	7.6	20.0	12.3	2.8	1.6	0.5	1.1

S_m : Monthly standard deviation = $S_d/(30)^{.5}$
S_d : Daily standard deviation
VF_m: Monthly variability factor
VF_d: Daily variability factor

* : For plants with more than 100 observations: $VF_d = \frac{\text{99th Percentile}}{\text{Average}}$

TABLE A-35

LONG-TERM DATA ANALYSIS

Plant : 0612
Subcategory: Steelmaking, Electric Furnace
Treatment : Lime Precipitation/Filtration

	Daily Maximum Analysis						Monthly Average Analysis	
Pollutant	No. of Obs	Min	Max	Ave	S_d	VF_d*	S_m	VF_m
TSS	12	4.0	14.0	8.8	3.3	1.9	0.6	1.1
Cadmium	12	0.02	0.5	0.07	0.1	5.5	0.02	1.5
Chromium	12	0.05	2.9	0.9	0.9	3.2	0.2	1.4
Copper	12	0.01	0.5	0.08	0.1	5.4	0.02	1.4
Nickel	12	0.05	0.1	0.08	0.03	2.0	0.005	1.1
Lead	12	0.03	0.8	0.2	0.2	3.1	0.04	1.3
Zinc	12	0.1	0.7	0.3	0.1	2.2	0.02	1.1

S_m : Monthly standard deviation = $S_d/(30)^{.5}$
S_d : Daily standard deviation
VF_m: Monthly variability factor
VF_d: Daily variability factor

* : For plants with more than 100 observations: $VF_d = \frac{\text{99th Percentile}}{\text{Average}}$

FIGURE A-1
LOG-PROBABILITY PLOT
PLANT 0112C-334
FILTRATION

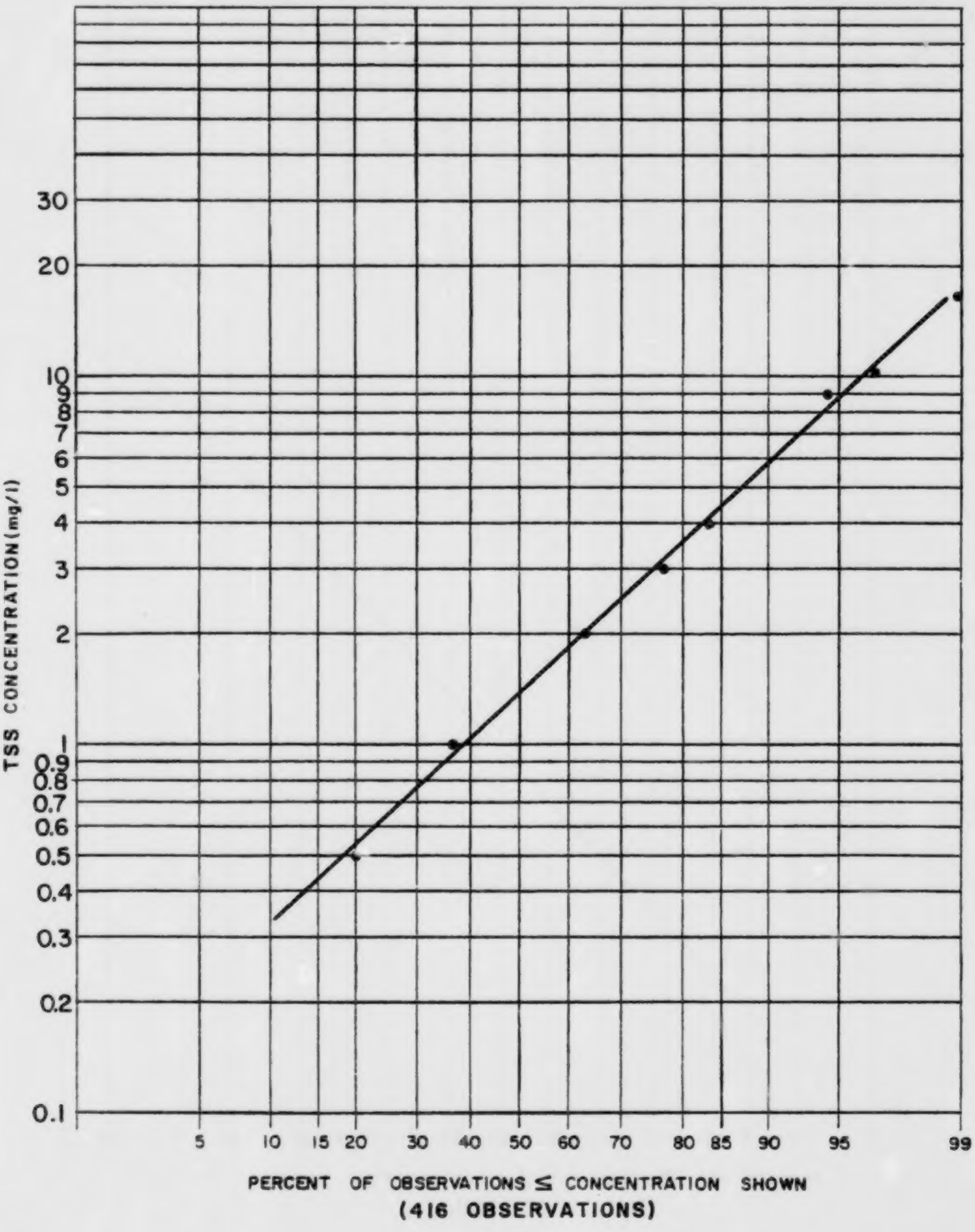


FIGURE A-2
LOG-PROBABILITY PLOT
PLANT 0112C-334
FILTRATION

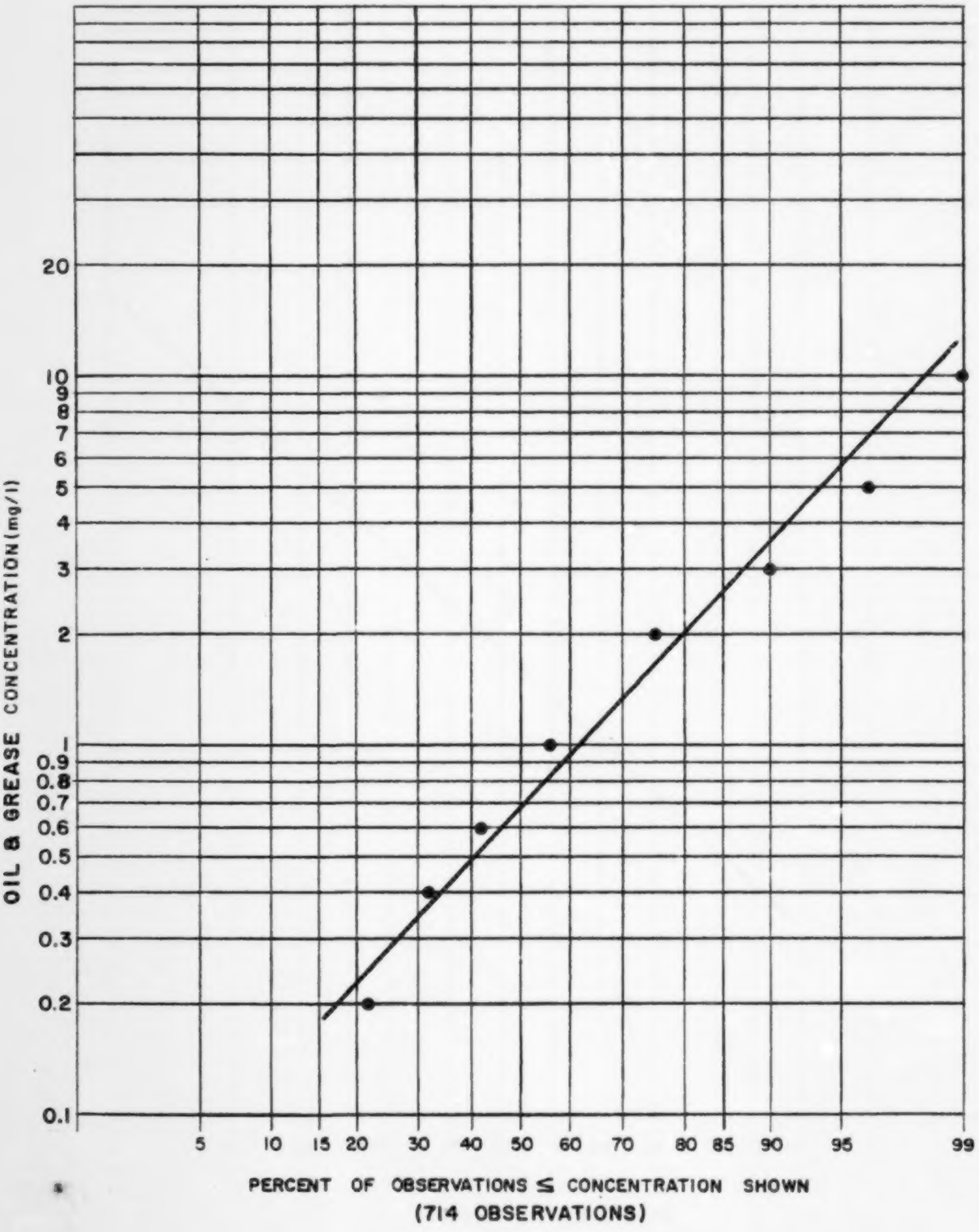


FIGURE A-3
LOG-PROBABILITY PLOT
PLANT 0684H-5C
CLARIFIER

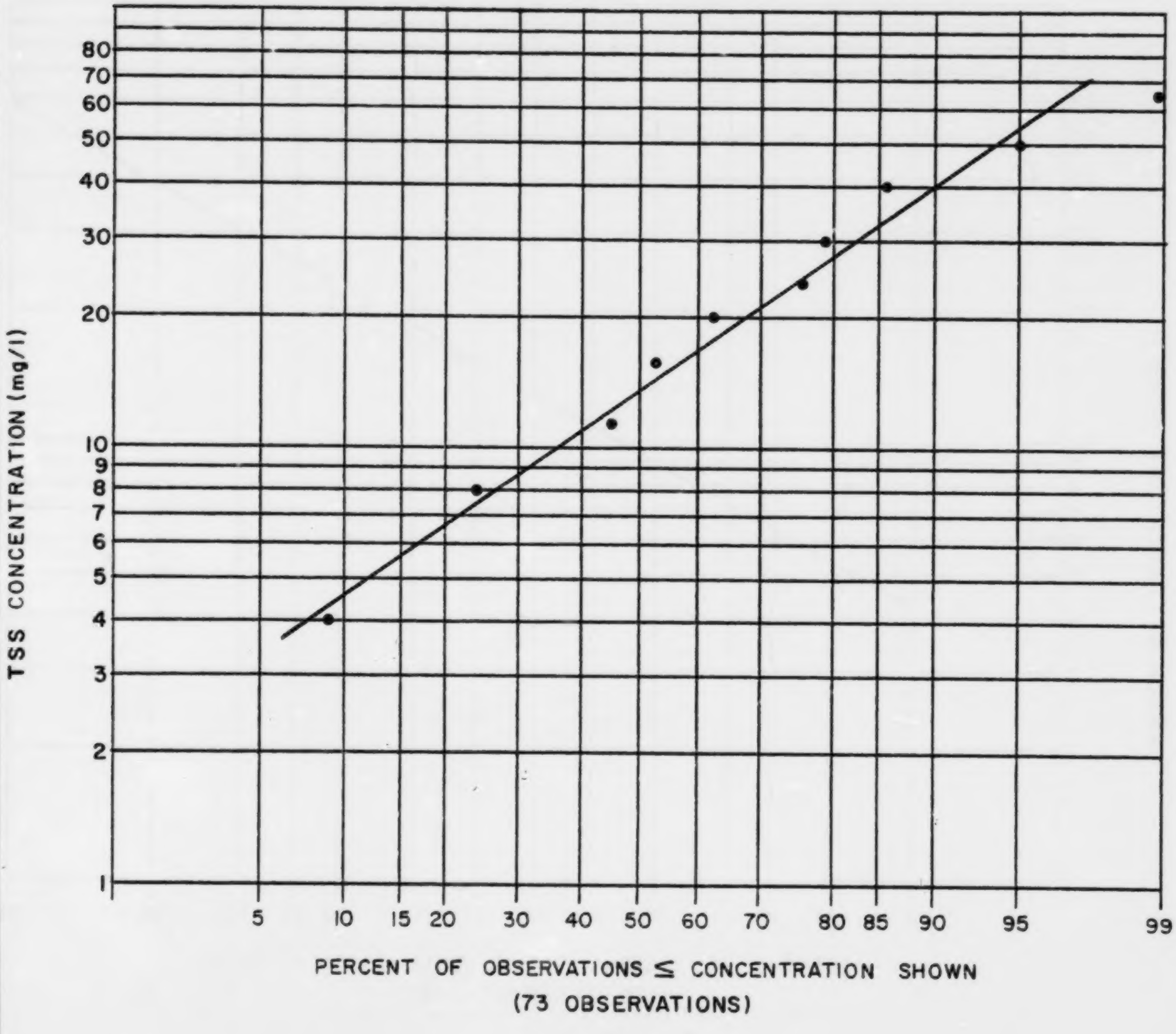
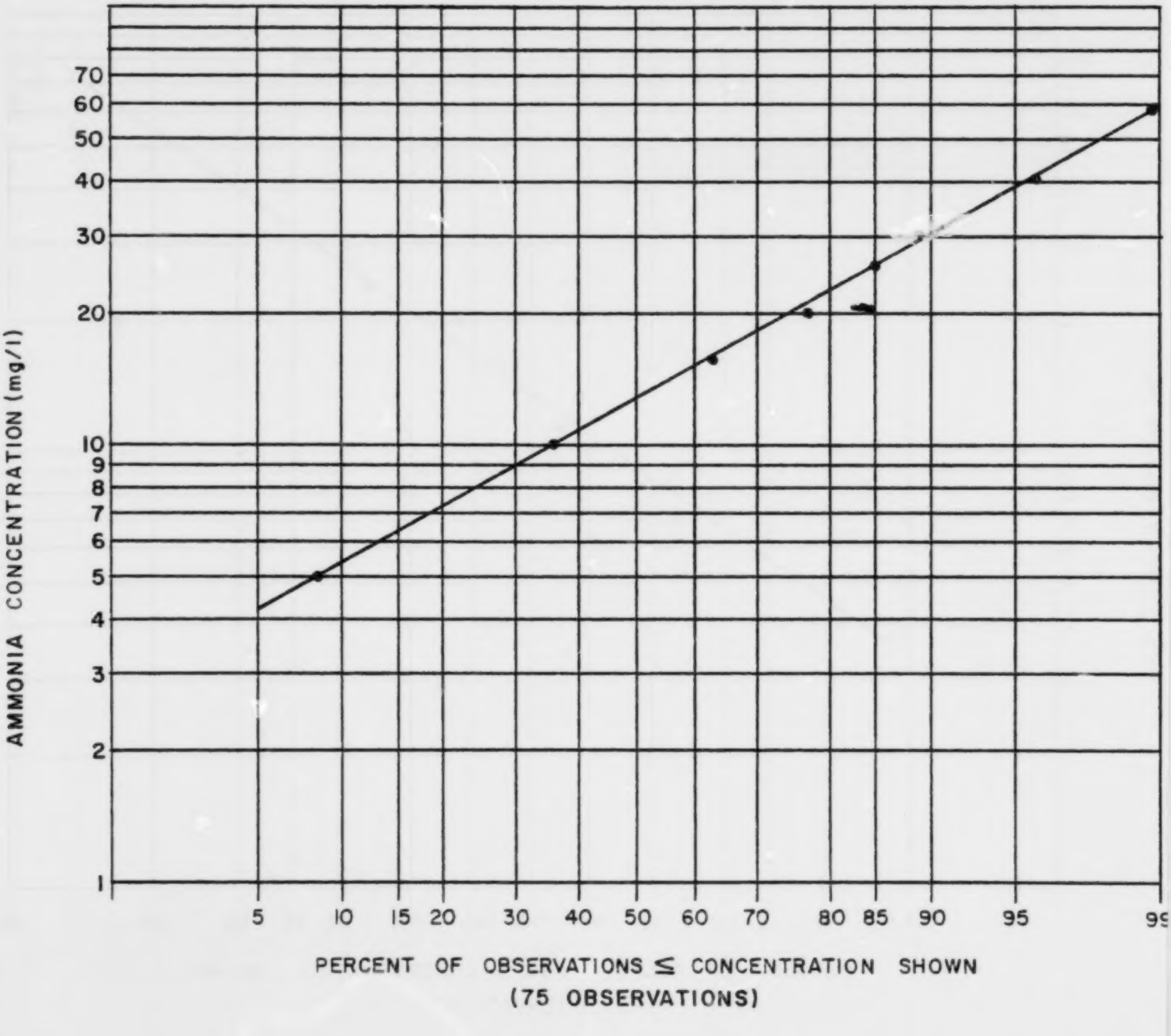


FIGURE A-4
LOG-PROBABILITY PLOT
PLANT 0684H-5C
CLARIFIER



APPENDIX B

IRON AND STEEL PLANT INVENTORY

REF/PLT	COMPANY OR PLANT NAME CITY	STATE	ZIP	FORMER REF/PLT	GROUP	SUBCATEGORIES
0004	ACCO BRIDGEPORT	CT	06602			
A	PAGE FENCE DIVISION MONESSEN	PA	15062			
B	AMERICAN CHAIN DIVISION YORK	PA	17403			
C	CABLE CONTROLS DIVISION ADRIAN	MI	49221			
0008	ADCOM METALS COMPANY, INC. JACKSONVILLE	FL	32202			
A	ADCOM METALS COMPANY, INC. NICHOLASVILLE	KY	40356			
B	CONTAINER WIRE PRODUCTS COMPANY JACKSONVILLE	FL	32202			
0012	ALABAMA BY-PRODUCTS CORPORATION BIRMINGHAM	AL	35202		E	
A	TARRANT COKE PLANT TARRANT	AL	35217		D	A
B	CONSHOHOCKEN COKE PLANT CONSHOHOCKEN	PA	19428	0016A	D	A
0016	ALAN WOOD STEEL COMPANY CONSHOHOCKEN	PA	19428		DE	G
A	SEE 0012B					
B	ALAN WOOD STEEL COMPANY IVY ROCK	PA	19428			
C	ALAN WOOD COATED METALS CORNWELLS HEIGHTS	PA	19020			
0020	ALLEGHENY LUDLUM STEEL CORP. PITTSBURGH	PA	15222		E	
A	ALLEGHENY LUDLUM STEEL COPRORATION PITTSBURGH	PA	15222			
B	BRACKENRIDGE PLANT BRACKENRIDGE	PA	15014		B	G,I,K,M,O,Q,S,W,X
C	WEST LEECHBURG LEECHBURG	PA	15656		C	R,S,W
D	BAR PRODUCTS DIVISION DUNKIRK	NY	14048			
E	BAR PRODUCTS DIVISION WATERVLIET	NY	12189			
F	AJAX FORGING AND CASTING COMPANY FERNDALE	MI	48220			
G	SPECIAL METALS CORPORATION NEW HARTFORD	NY	13413			
H	WALLINGFORD STEEL WALLINGFORD	CT	06492			

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IRON AND STEEL PLANT INVENTORY

REF/PLT	COMPANY OR PLANT NAME CITY	STATE	ZIP	FORMER REF/PLT	GROUP	SUBCATEGORIES
I	ARNOLD ENGINEERING COMPANY MARENGO	IL	60152		D	I
J	CARMET COMPANY PITTSBURGH	PA	15222			
K	ALJAX STEEL CORPORATION BUFFALO	NY	14207		D	I
L	NEW CASTLE PLANT NEW CASTLE	IN	47362		C	S,W
0024	ALLIED CHEMICAL CORPORATION MORRISTOWN	NJ	07960		E	
A	ASHLAND COKE PLANT ASHLAND	KY	41101		D	A
B	DETROIT COKE PLANT DETROIT	MI	48231		D	A
C	SEE 0402					
0028	ALLIED TUBE AND CONDUIT CORPORATION HARVEY	IL	60426			
0032	AMERICAN CAST IRON PIPE COMPANY BIRMINGHAM	AL	35202		E	
A	ACIPCO STEEL PRODUCTS DIVISION BIRMINGHAM	AL	35207		D	I
0036	AMERICAN COMPRESSED STEEL CORPORATION CINCINNATI	OH	45202			
0040	AMERICAN HOIST AND DERRICK CO. ST. PAUL	MN	55107		E	
A	BAY CITY STEEL CASTINGS DIVISION BAY CITY	MI	48706		D	I
0044	AMERON, INC. MONTEREY PARK	CA	91754		E	
A	AMERON STEEL AND WIRE DIVISION ETIWANDA	CA	91739		B	I,L
0048	AMPCO-PITTSBURGH CORPORATION MILWAUKEE	WI	53201		E	
A	WYCKOFF STEEL DIVISION PITTSBURGH	PA	15219			
B	WYCKOFF STEEL DIVISION AMBRIDGE	PA	15003			
C	WYCKOFF STEEL DIVISION PLYMOUTH	MI	48170			
D	WYCKOFF STEEL DIVISION CHICAGO	IL	60690			
E	WYCKOFF STEEL DIVISION NEWARK	NJ	07102			
F	WYCKOFF STEEL DIVISION PUTNAM	CT	06260		C	O

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IRON AND STEEL PLANT INVENTORY

REF/PLT	COMPANY OR PLANT NAME CITY	STATE	ZIP	FORMER REF/PLT	GROUP	SUBCATEGORIES
0052	AMSTED INDUSTRIES, INC. CHICAGO	IL	60690			
A	MAC WHYTE COMPANY KENOSHA	WI	53140			
0056	ANGELL NAIL AND CHAPLET COMPANY CLEVELAND	OH	44105			
0060	ARMCO STEEL CORPORATION MIDDLETOWN	OH	45043		AE	A,C,D,G,H,K,L,M,O,P,R, S,T,U,W
A	HAMILTON PLANT HAMILTON	OH	45011		A	A,D
B	ASHLAND WORKS ASHLAND	KY	41101		A	C,D,F,M,O,R,S,T
C	AMBRIDGE WORKS AMBRIDGE	PA	15003		C	N,P,Q
D	BUTLER WORKS BUTLER	PA	16001		B	J,K,L,M,O,Q,R,S,W,X,Z
E	ZANESVILLE PLANT ZANESVILLE	OH	43701		C	S,W
F	HOUSTON WORKS HOUSTON	TX	77015		A	A,C,D,I,J,K,M,N,O,P
G	KANSAS CITY WORKS KANSAS CITY	MO	64125		B	J,M,N,O,T
H	SAND SPRING WORKS SAND SPRING	OK	74063		B	I,L,M
I	BALTIMORE WORKS BALTIMORE	MD	21203		B	I,M,N,S,W,X
J	NATIONAL SUPPLY COMPANY TORRANCE	CA	90509		B	I,K
K	MARION WORKS MARION	OH	43302		B	I,L,M
L	HITCO DIVISION ATLANTA	GA	30318		C	R
M	LEGGET AND PLATT DIVISION CARTHAGE	MO	64836		C	O
N	ADVANCED MATERIALS DIVISION HOUSTON	TX	77044		C	P,W,Z
O	TUBE ASSOCIATES HOUSTON	TX	77028			
P	WILDWOOD PLANT WILDWOOD	FL	32785		C	P,W
Q	UNION WIRE ROPE					
R	MIDDLETOWN FABRICATING MIDDLETOWN	OH	45042		C	P,T
S	UNION WIRE ROPE KANSAS CITY	MO	64126		C	O,T
0064	BARNES GROUP, INC. BRISTOL	CT	06010			
A	WALLACE BARNES STEEL DIVISION BRISTOL	CT	06010			

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IRON AND STEEL PLANT INVENTORY

REF/PLT	COMPANY OR PLANT NAME CITY	STATE	ZIP	FORMER REF/PLT	GROUP	SUBCATEGORIES
0068	ATLANTIC STEEL COMPANY ATLANTA	GA	30301		BE	I,M,N,Q,R,T,W,Z
A	ATLANTA BUILDING SYSTEMS, INC. ATLANTA	GA	30301			
B	CARTERSVILLE FACILITY CARTERSVILLE	GA	30120		B	I,L,N
0072	ATLANTIC WIRE COMPANY BRANFORD	CT	06405			
0076	AUBURN STEEL COMPANY, INC. AUBURN	NY	13021		BE	I,L
0080	AUTOMATION INDUSTRIES, INC. LOS ANGELES	CA	90002		E	
A	HARRIS TUBE DIVISION LOS ANGELES	CA	90002		C	P
B	SO. WEST STEEL RLLNG. MILLS, INC. LOS ANGELES	CA	90002		D	I
0084	AZCON CORPORATION KNOXVILLE	TN	37921		E	
A	KNOXVILLE IRON DIVISION KNOXVILLE	TN	37921		B	I,L
0088	BABCOCK AND WILCOX NEW YORK	NY	10017		E	
A	TUBULAR PRODUCTS DIVISION BEAVER FALLS	PA	15010		B	I,K,M,N,P,Q,R,W,X
B	TUBULAR PRODUCTS DIVISION ALLIANCE	OH	44601		C	Q
C	TUBULAR PRODUCTS DIVISION MILWAUKEE	WI	53201		C	P,W,Z
D	TUBULAR PRODUCTS DIVISION BEAVER FALLS	PA	15010		C	M,N,Q,W
0092	BARON DRAWN STEEL CORPORATION TOLEDO	OH	43607			
0096	PARRY STEEL CORPORATION DETROIT	MI	48238			
0104	BEKAERT STEEL WIRE CORPORATION NEW YORK	NY	10017			
A	BEKAERT STEEL WIRE CORPORATION ROME	GA	30161			
B	BEKAERT STEEL WIRE CORPORATION RENO	NV	89501			
C	BEKAERT STEEL WIRE CORPORATION ACWORTH	GA	30101			

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IRON AND STEEL PLANT INVENTORY

REF/PLT	COMPANY OR PLANT NAME CITY	STATE	ZIP	FORMER REF/PLT	GROUP	SUBCATEGORIES
0108	BERGER INDUSTRIES, INC. MASPETH	NY	11378			
A	BERGER INDUSTRIES, INC. METUCHEN	NJ	08840			
0112	BETHLEHEM STEEL CORPORATION BETHLEHEM	PA	18016		AE	A,C,D,F,I,K,M,N,Q
A	SPARROWS POINT SPARROWS POINT	MD	21219		A	A,C,D,G,H,M,N,O,P,Q,S,T,W,Z
B	LACKAWANNA PLANT BUFFALO	NY	14219		A	A,C,D,G,H,K,M,N,O,Q,R,S,T
C	JOHNSTOWN PLANT JOHNSTOWN	PA	15907		A	A,C,D,E,H,M,N,O,Q,W,Z
D	BURNS HARBOR CHESTERTON	IN	46304		A	A,C,D,G,L,M,O,Q,R,S,Z
E	STEELTON PLANT STEELTON	PA	17113		B	I,M,N,P
F	LOS ANGELES PLANT LOS ANGELES	CA	90051		B	I,M,N,Q,T,Z
G	SEATTLE PLANT SEATTLE	WA	98124		B	I,M,N,Q,T
H	WILLIAMSPORT PLANT WILLIAMSPORT	PA	17701		C	R,T,W
I	LEBANON PLANT LEBANON	PA	17042		C	N,Q,T,Z
J	SAN FRANCISCO PLANT SAN FRANCISCO	CA	94080		C	N
K	MORGANTOWN PLANT MORGANTOWN	PA	19543			
0116	BIRDSBORO CORPORATION BIRDSBORO	PA	19508		DE	I
0120	BISHOP TUBE COMPANY FRAZER	PA	19355			
0124	BLAIR STRIP STEEL COMPANY NEW CASTLE	PA	16103			
0128	BLISS AND LAUGHLIN INDUSTRIES, INC. OAK BROOK	IL	60521			
A	BLISS AND LAUGHLIN STEEL COMPANY DIV. HARVEY	IL	60426			
B	BLISS AND LAUGHLIN STEEL COMPANY DIV. DETROIT	MI	48089			
C	BLISS AND LAUGHLIN STEEL COMPANY DIV. MEDINA	OH	44256			
D	BLISS AND LAUGHLIN STEEL COMPANY DIV. LOS ANGELES	CA	90040			
E	BLISS AND LAUGHLIN STEEL COMPANY DIV. SEATTLE	WA	98108			
F	BLISS AND LAUGHLIN STEEL COMPANY DIV. HOUSTON	TX	77023			

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IRON AND STEEL PLANT INVENTORY

REF/PLT	COMPANY OR PLANT NAME CITY	STATE	ZIP	FORMER REF/PLT	GROUP	SUBCATEGORIES
0132	BORDER STEEL MILLS, INC. VINTON	TX	79912		BE	I,L
0136	BORG-WARNER CORPORATION CHICAGO	IL	60604		E	
A	BW STEEL, INC CHICAGO HEIGHTS	IL	60411			
B	CALUMET STEEL COMPANY CHICAGO HEIGHTS	IL	60411		B	I,L,N
C	FRANKLIN STEEL COMPANY FRANKLIN	PA	16323		C	N
D	SEE 0430C					
E	INGERSOLL PRODUCTS DIVISION CHICAGO	IL	60643			
0140	BORTZ COAL COMPANY UNIONTOWN	PA	15401			
A	BORTZ COAL COMPANY SMITHFIELD	PA	15478			
0144	BUCKEYE STEEL CASTINGS COMPANY COLUMBUS	OH	43215		DE	I
0148	BUCYRUS-ERIE COMPANY SOUTH MILWAUKEE	WI	53172		DE	I
A	GLASSPORT GLASSPORT	PA	15045		B	H,I
0152	BUNDY CORPORATION DETROIT	MI	48226			
A	BUNDY CORPORATION WINCHESTER	KY	40391			
B	BUNDY CORPORATION COLDWATER	MI	49036			
C	BUNDY CORPORATION MT. CLEMENS	MI	48043			
D	BUNDY CORPORATION WARREN	MI	48089			
E	BUNDY CORPORATION HOMETOWN	PA	18252			
F	BUNDY CORPORATION CYNTHIANA	KY	41031			
G	BUNDY CORPORATION MALVERN	PA	19355			
0156	CABOT CORPORATION BOSTON	MA	02110		E	
A	MACHINERY DIVISION PAMPA	TX	79065		B	I,K
B	STELLITE DIVISION KOKOMO	IN	46901		B	C,I

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IRON AND STEEL PLANT INVENTORY

REF/PLT	COMPANY OR PLANT NAME CITY	STATE	ZIP	FORMER REF/PLT	GROUP	SUBCATEGORIES
0160	CALIFORNIA STEEL AND TUBE CITY OF INDUSTRY	CA	91744			
0164	CAL-METAL CORPORATION IRWINDALE	CA	91706			
0168	CAMERON IRON WORKS, INC. HOUSTON	TX	7700		BE	I,K
0172	G.O. CARLSON, INC. THORNDALE	PA	19372			
0176	CARPENTER TECHNOLOGY CORPORATION READING	PA	19601		BE	I,M,N,O,Q,R,S,W,X,Z
A	CARPENTER STEEL DIVISION BRIDGEPORT	CT	06607		D	I
B	CARPENTER STEEL DIVISION READING	PA	19601			
C	UNION PLANT TUBE DIVISION UNION	NJ	07083		C	P,W
D	JAMESBURG PLANT TUBE DIVISION CRANBURY	NJ	08512		C	P,W
0180	CASCADE STEEL ROLLING MILLS, INC. MCMINNVILLE	OR	97128		BE	I,L
0184	CAVERT WIRE COMPANY, INC. UNIONTOWN	PA	15401			
0188	CECO CORPORATION CHICAGO	IL	60650		E	
A	LEMONT MANUFACTURING COMPANY LEMONT	IL	60439		B	I,M
B	MILTON MANUFACTURING COMPANY MILTON	PA	17847		B	I,N,M
C	SOUTHERN ELECTRIC STEEL COMPANY BIRMINGHAM	AL	35202		B	I,L,N
0192	CENTRAL STEEL TUBE COMPANY CLINTON	IA	52732			
0196	CF & I STEEL CORPORATION PUEBLO	CO	81002		E	
A	PUEBLO PLANT PUEBLO	CO	81004		A	A,C,D,F,I,L,M,N,P,Q,T
0200	CHAMPION STEEL COMPANY ORWELL	OH	44076			
020[illegible]	CHAPARRAL STEEL COMPANY MIDLOTHIAN	TX	76065		BE	I,L
0200	CHRISTIE COAL AND COKE COMPANY NORTON	VA	24273			

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IRON AND STEEL PLANT INVENTORY

REF/PLT	COMPANY OR PLANT NAME CITY	STATE	ZIP	FORMER REF/PLT	GROUP	SUBCATEGORIES
0212	CITIZENS GAS AND COKE UTILITY				DE	A
	INDIANAPOLIS	IN	46202			
0216	COLUMBIA STEEL CASTING CO., INC.				DE	I
	PORTLAND	OR	97203			
0220	COLUMBIA TOOL STEEL COMPANY					
	CHICAGO HEIGHTS	IL	60411			
0224	COLUMBIAN STEEL TANK COMPANY					
	KANSAS CITY	MO	64101			
0226	COMMERCIAL METALS, INC.				BE	I,L
	DALLAS	TX	75247	0764		
A	ARKANSAS STEEL ROLLING MILLS, INC.					
	MAGNOLIA	AR	71753	0764A		
0228	CONSOLIDATED METALS CORPORATION					
	NEWTON	NJ	07860			
0232	CONSTELLATION STEEL MILL EQUIPMENT CORP.					
	CINCINNATI	OH	45216			
0236	CONTINENTAL COPPER AND STEEL INDUSTRIES				E	
	CRANFORD	NJ	07016			
A	BRAEBURN ALLOY STEEL DIVISION				D	I
	LOWER BURRELL	PA	15068			
0240	COPPERWELD CORPORATION				E	
	PITTSBURGH	PA	15219			
A	COPPERWELD STEEL COMPANY				B	I,K,L,M,N,Q
	WARREN	OH	44482			
B	OHIO STEEL TUBE COMPANY				C	P,Q,Z
	SHELBY	OH	44875			
C	REGAL TUBE COMPANY				C	P,Q,Z
	CHICAGO	IL	60638			
D	BIMETALLICS DIVISION					
	GLASSPORT	PA	15045			
E	FLEXCO WIRE DIVISION					
	OSWEGO	NY	13126			
0244	COREY STEEL COMPANY					
	CICERO	IL	60650			
0248	COLT INDUSTRIES				E	
	NEW YORK	NY	10022			
A	ALLOY DIVISION				C	A,D,F,K,N,Q
	MIDLAND	PA	15059			
B	STAINLESS STEEL DIVISION				C	I,K,L,S,W,X
	MIDLAND	PA	15059			

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IRON AND STEEL PLANT INVENTORY

REF/PLT	COMPANY OR PLANT NAME CITY	STATE	ZIP	FORMER REF/PLT	GROUP	SUBCATEGORIES
C	SPECIALTY METALS DIVISION GEDDES	NY	13209		C	M,N,S,W,Z
D	TRENT TUBE DIVISION EAST TROY	WI	53120			
E	TRENT TUBE DIVISION FULLERTON	CA	92634			
F	TRENT TUBE DIVISION CARROLLTON	GA	30117			
G	TRENT TUBE DIVISION BREMEN	GA	30110			
0252	CUMBERLAND STEEL COMPANY CUMBERLAND	MD	21502			
0256	CYCLOPS CORPORATION PITTSBURGH	PA	15228		E	
A	DETROIT STRIP DIVISION DETROIT	MI	48217		C	Q,S
B	DETROIT STRIP DIVISION NEW HAVEN	CT	06507		C	Q,S
C	EMPIRE DETROIT STEEL DIVISION MANSFIELD	OH	44901		B	F,I
D	EMPIRE DETROIT STEEL DIVISION DOVER	OH	44622			
E	EMPIRE DETROIT STEEL DIVISION PORTSMOUTH	OH	45662		A	A,D,H
F	SAWHILL TUBULAR DIVISION WHEATLAND	PA	16161		C	P,Q,W
G	SAWHILL TUBULAR DIVISION SHARON	PA	16146		C	P,Q,T
H	SAWHILL TUBULAR DIVISION MINNEAPOLIS	MN	55406			
I	TEX-TUBE DIVISION HOUSTON	TX	77007			
J	UNIVERSAL CYCLOPS SPECIALTY STEEL DIV. PITTSBURGH	PA	15228			
K	BRIDGEVILLE PLANT BRIDGEVILLE	PA	15017		B	I,M,N,X,Y
L	PITTSBURGH PLANT PITTSBURGH	PA	15201		C	O,S,W,X
M	ALIQUIPPA FORGE DEPARTMENT ALIQUIPPA	PA	15001			
N	TITUSVILLE PLANT TITUSVILLE	PA	16354		B	I,N,S,W,X,Z
O	COSHOCTON PLANT COSHOCTON	OH	43812		C	S,W,X,Z
0260	DAMASCUS STEEL CASTING COMPANY NEW BRIGHTON	PA	15066		DE	I

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IRON AND STEEL PLANT INVENTORY

REF/PLT	COMPANY OR PLANT NAME CITY	STATE	ZIP	FORMER REF/PLT	GROUP	SUBCATEGORIES
0264	DAVIS WALKER CORPORATION LOS ANGELES	CA	90040			
A	DAVIS WALKER CORPORATION CITY OF INDUSTRY	CA	91744			
B	DAVIS WALKER CORPORATION RIVERSIDE	CA	92501			
C	DAVIS WALKER CORPORATION KENT	WA	98031			
0272	DONNER-HANNA COKE CORPORATION BUFFALO	NY	14220		DE	A
0276	DONOVAN STEEL TUBE COMPANY TOLEDO	OH	43611			
0280	EASTERN GAS AND FUEL ASSOCIATION PHILADELPHIA	PA	19137		E	
A	EASTERN ASSOCIATION COAL CORPORATION PITTSBURGH	PA	15219			
B	PHILADELPHIA COKE DIVISION PHILADELPHIA	PA	19137		D	A
0284	EASTMET CORPORATION COCKEYSVILLE	MD	21030		E	
A	EASTERN STAINLESS STEEL COMPANY BALTIMORE	MD	21224		B	L,O,S,W,X
0288	EDGEWATER CORPORATION OAKMONT	PA	15139		E	
A	EDGEWATER STEEL COMPANY OAKMONT	PA	15139		D	I
C	JANNEY CYLINDER COMPANY PHILADELPHIA	PA	19136			
0292	EDWARDS COMPANY, E.H. SAN FRANCISCO	CA	94080			
0296	ELECTRALLOY CORPORATION NEW YORK	NY	10019			
A	ELECTRALLOY CORPORATION OIL CITY	PA	16301			
0300	ELLIOT BROTHERS STEEL COMPANY NEW CASTLE	PA	16103			
0304	EMPIRE COKE COMPANY HOLT	AL	35401			
0308	EMPIRE STEEL CASTINGS INC. READING	PA	19603			
A	EMPIRE STEEL CASTINGS INC. TEMPLE	PA	19560			
0312	FITZSIMMONS STEEL COMPANY YOUNGSTOWN	OH	44501			

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IRON AND STEEL PLANT INVENTORY

REF/PLT	COMPANY OR PLANT NAME CITY	STATE	ZIP	FORMER REF/PLT	GROUP	SUBCATEGORIES
0316	FLORIDA STEEL CORPORATION TAMPA	FL	33623		BE	I,L,N
A	INDIANTOWN STEEL MILL DIVISION INDIANTOWN	FL	33456		B	I,L,N
B	CHARLOTTE STEEL MILL DIVISION CHARLOTTE	NC	28213		B	I,L,N
C	JACKSONVILLE STEEL MILL DIVISION JACKSONVILLE	FL	32234		C	N
0320	FORD MOTOR COMPANY DEARBORN	MI	48121		AE	A,D,F,I,M,N,O,R,S
0324	FORT HOWARD STEEL AND WIRE GREEN BAY	WI	54305			
0328	FOSBRINK MACHINE COMPANY CONNELLSVILLE	PA	15425			
0332	GENERAL CABLE CORPORATION GREENWICH	CT	06830			
A	INDIANA STEEL AND WIRE DIVISION MUNCIE	IN	47302			
0336	GENERAL MOTORS CORPORATION DETROIT	MI	48202			
A	GENERAL MOTORS WAUKEGAN	IL	60085			
0340	GENERAL STEEL INDUSTRIES, INC. ST. LOUIS	MO	63105		E	
A	NATIONAL ROLL DIVISION AVONMORE	PA	15618		D	I
0344	GILBERT AND BENNETT MANUFACTURING CO. GEORGETOWN	CT	06829			
A	GILBERT AND BENNETT MANUFACTURING CO. BLUE ISLAND	IL	60406			
B	COATINGS ENGINEERING CORPORATION SUDBURY	MA	01776			
0348	GREAT LAKES CARBON CORPORATION NEW YORK	NY	10017		E	
A	MISSOURI COKE AND CHEMICAL DIV. ST. LOUIS	MO	63111		D	A
0352	GREER STEEL COMPANY DOVER	OH	44622			
A	GREER STEEL COMPANY FERNDALE	MI	48220			

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IRON AND STEEL PLANT INVENTORY

REF/PLT	COMPANY OR PLANT NAME CITY	STATE	ZIP	FORMER REF/PLT	GROUP	SUBCATEGORIES
0356	HARSCO CORPORATION CAMP HILL	PA	17011		E	
A	HARRISBURG STEEL COMPANY HARRISBURG	PA	17105			
B	QUAKER ALLOY CASTING COMPANY MYERSTOWN	PA	17067		D	I
0360	HAWAIIAN WESTERN STEEL LIMITED EWA	HI	96706		DE	I
0364	HEPPENSTALL COMPANY PITTSBURGH	PA	15201			
A	MIDVALE-HEPPENSTALL PHILADELPHIA	PA	19140			
0368	HOOVER BALL AND BEARING COMPANY SOLON	OH	44139			
A	CUYAHOGA STEEL AND WIRE DIVISION SOLON	OH	44139			
0372	HYDE PARK FOUNDRY AND MACHINE COMPANY HYDE PARK	PA	15641			
0376	IGOE BROTHERS INC. NEWARK	NJ	07114			
0380	INDIANA GAS AND CHEMICAL CORPORATION TERRE HAUTE	IN	47808			
0384	INLAND STEEL COMPANY CHICAGO	IL	60603		E	
A	INDIANA HARBOR WORKS EAST CHICAGO	IN	46312		A	A,C,D,G,H,I,L,M,N,O,Q, R,S,T,Z
0388	INTERCOASTAL STEEL CORPORATION CHESAPEAKE	VA	23324		E	
A	GILMERTON PLANT CHESAPEAKE	VA	23323		D	I
0392	INTERCONTINENTAL STEEL CORPORATION CHICAGO	IL	60628			
0396	INTERLAKE, INC. OAK BROOK	IL	60521		E	
A	IRON AND STEEL DIVISION SOUTH CHICAGO	IL	60617		A	A,C,D
C	TOLEDO PLANT TOLEDO	OH	43605		A	A,D
D	RIVERDALE STATION RIVERDALE	IL	60627		B	F,M,N,O,R,S
E	NEWPORT WILDER PLANT NEWPORT	KY	41072		B	I,M,P,Q,S
F	GARY STEEL SUPPLY COMPANY BLUE ISLAND	IL	60406			
G	BEVERLY PLANT BEVERLY	OH	45715			

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IRON AND STEEL PLANT INVENTORY

REF/PLT	COMPANY OR PLANT NAME CITY	STATE	ZIP	FORMER REF/PLT	GROUP	SUBCATEGORIES
H	ALABAMA METALLURGICAL CORPORATION SELMA	AL	36701			
I	HOEGANAES CORPORATION RIVERTON	NJ	08077			
0400	SEE 0946					
A	SEE 0946A					
0402	IRONTON COKE COMPANY IRONTON	OH	45638	0024C	D	A
0404	ITT HARPER, INC. MORTON GROVE	IL	60053		DE	I
0408	IVY STEEL AND WIRE COMPANY JACKSONVILLE	FL	32205			
0412	JACKSON IRON AND STEEL COMPANY JACKSON	OH	45640			
0416	JAMES STEEL AND TUBE COMPANY ROYAL OAK	MI	48067			
A	JAMES STEEL AND TUBE COMPANY MADISON HEIGHTS	MI	48071			
0420	JERSEY SHORE STEEL COMPANY JERSEY SHORE	PA	17740			
A	JERSEY SHORE STEEL COMPANY SOUTH AVIS	PA	17721			
0424	JESSOP STEEL COMPANY WASHINGTON	PA	15301		BE	I,M,N,O,W,X
A	GREEN RIVER STEEL OWENSBORO	KY	42301		B	I,K
0426	JIM WALTER RESOURCES BIRMINGHAM	AL	35202	0848	AE	A,D
0428	JEWELL SMOKELESS COAL CORPORATION KNOXVILLE	TN	37902			
A	JEWELL SMOKELESS COAL CORPORATION VANSANT	VA	24656			
0430	JOHNSON STEEL AND WIRE COMPANY WORCESTER	MA	01607	0920H	E	
A	AKRON PLANT AKRON	OH	44309	0920I		
B	LOS ANGELES PLANT LOS ANGELES	CA	90059	0920J		
C	INGERSOLL STEEL NEW CASTLE	IN	47362	01360	B	I,M,C

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IRON AND STEEL PLANT INVENTORY

REF/PLT	COMPANY OR PLANT NAME CITY	STATE	ZIP	FORMER REF/PLT	GROUP	SUBCATEGORIES
0432	JONES AND LAUGHLIN STEEL CORP. PITTSBURGH	PA	15230		E	
A	ALIQUIPPA WORKS ALIQUIPPA	PA	15001		A	A,C,D,F,L,M,N,O,P,Q,S, T,Z
B	PITTSBURGH WORKS PITTSBURGH	PA	15203		A	A,D,H,M,N,O,Q,S,T
C	CLEVELAND WORKS CLEVELAND	OH	44101		A	C,D,F,I,M,O,R,S
D	HENNEPIN WORKS HENNEPIN	IL	61327		C	R,S,T
E	OIL CITY WORKS OIL CITY	PA	16301		C	Q,W
F	JONES AND LAUGHLIN STEEL GAINESVILLE	TX	76240			
G	JONES AND LAUGHLIN STEEL MUNCY	PA	17756			
H	JONES AND LAUGHLIN STEEL HAMMOND	IN	46320			
I	JONES AND LAUGHLIN STEEL WILLIMANTIC	CT	06226			
J	WARREN PLANT WARREN	MI	48090		B	I,M,N
K	JONES AND LAUGHLIN LOUISVILLE	OH	44641			
L	YOUNGSTOWN WORKS YOUNGSTOWN	OH	44501		C	Q,W,X
M	INDIANAPOLIS WORKS INDIANAPOLIS	IN	46241		C	Q
N	JONES AND LAUGHLIN LOS ANGELES	CA	90052			
O	JONES AND LAUGHLIN NILES	OH	44446			
P	JONES AND LAUGHLIN NEW KENSINGTON	PA	15068			
0436	JORGENSEN CO. E.P. LOS ANGELES	CA	90054		BE	I,K
0440	JOSLYN MANUFACTURING AND SUPPLY CO. CHICAGO	IL	60606		E	
A	JOSLYN STAINLESS STEELS DIVISION FORT WAYNE	IN	46804		B	I,M,N,W,X
0444	JUDSON STEEL CORPORATION EMERYVILLE	CA	94608		BE	I,L
0448	KAISER STEEL CORPORATION OAKLAND	CA	94612		E	
A	STEEL MANUFACTURING DIVISION FONTANA	CA	92335		A	A,C,D,F,H,M,N,O,P,R,S, T,Z
B	KAISER STEEL CORPORATION NAPA	CA	94558			

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IRON AND STEEL PLANT INVENTORY

REF/PLT	COMPANY OR PLANT NAME CITY	STATE	ZIP	FORMER REF/PLT	GROUP	SUBCATEGORIES
0452	KENNAMETAL INC. LATROBE	PA	15650			
0456	KENTUCKY ELECTRICAL STEEL COMPANY ASHLAND	KY	41101		E	
A	KENTUCKY ELECTRICAL STEEL CO. ASHLAND	KY	41101		B	I,L
0460	KEYSTONE CONSOLIDATED INDUSTRIES, INC. PEORIA	IL	61602		E	
A	KEYSTONE STEEL AND WIRE PEORIA	IL	61641		B	I,L,M,N,O,T
B	KEYSTONE STEEL AND WIRE CHICAGO HEIGHTS	IL	60411		C	N
C	SANTA CLARA PLANT SANTA CLARA	CA	95052		C	O,T
D	MID-STATES STEEL AND WIRE CRAWFORDSVILLE	IN	47933		C	O,T,Z
E	JACKSONVILLE PLANT JACKSONVILLE	FL	32201		C	O,T
F	MIDSTATES STEEL AND WIRE SHERMAN	TX	75091		C	O,T
G	GREENVILLE PLANT GREENVILLE	MS	38701		C	O,T,Z
H	CHICAGO STEEL AND WIRE CHICAGO	IL	60617		C	O,T,Z
0464	KOPPERS COMPANY, INC. PITTSBURGH	PA	15219		E	
A	ORGANIC MATERIALS DIVISION PITTSBURGH	PA	15219			
B	ST. PAUL ST. PAUL	MN	55104		D	A
C	ERIE ERIE	PA	16512		D	A
D	ORGANIC MATERIALS DIVISION KEARNY	NJ	07032			
E	WOODWARD COKE BESSEMER	AL	35020		D	A
0468	KORF INDUSTRIES, INC. CHARLOTTE	NC	28280		E	
A	MIDREX CORPORATION CHARLOTTE	NC	28280			
B	GEORGETOWN STEEL CORPORATION GEORGETOWN	SC	29440		B	I,L,N
C	GEORGETOWN FERREDUCTION CORPORATION GEORGETOWN	SC	29440			
D	ANDREWS WIRE CORPORATION ANDREWS	SC	29510			
E	ANDREWS WIRE OF TENNESSEE GALLATIN	TN	37066			
F	GEORGETOWN TEXAS STEEL CORPORATION BEAUMONT	TX	77704		B	I,L

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IRON AND STEEL PLANT INVENTORY

REF/PLT	COMPANY OR PLANT NAME CITY	STATE	ZIP	FORMER REF/PLT	GROUP	SUBCATEGORIES
0472	MICHAEL KRAL INDUSTRIES, INC. NEW YORK	NY	10019			
A	KOKOMO TUBE COMPANY KOKOMO	IN	46901			
B	VENANGO METALLURGICAL PRODUCTS OIL CITY	PA	16301			
0476	LACLEDE STEEL COMPANY ST. LOUIS	MO	63102		E	
A	ALTON PLANT ALTON	IL	62002		B	I,L,M,N,O,P,Q,T,W,Z
B	MADISON PLANT MADISON	IL	62060			
C	BEAUMONT PLANT BEAUMONT	TX	77706			
D	DALLAS PLANT DALLAS	TX	75206			
E	MEMPHIS PLANT MEMPHIS	TN	38107			
F	NEW ORLEANS PLANT NEW ORLEANS	LA	70126			
G	TAMPA PLANT TAMPA	FL	33611			
0480	LASALLE STEEL COMPANY CHICAGO	IL	60680			
A	HAMMOND PLANT HAMMOND	IN	46327			
B	KEYSTONE DRAWN STEEL COMPANY SPRING CITY	PA	19475			
C	FLUID POWER DIVISION CHICAGO	IL	60680			
D	FLUID POWER DIVISION GRIFFITH	IN	46319			
0488	LOFLAND STEEL MILL, INC. OKLAHOMA CITY	OK	73108			
0492	LONE STAR STEEL COMPANY DALLAS	TX	75235		E	
A	LONE STAR STEEL COMPANY LONE STAR	TX	75668		A	A,C,D,H,M,O,P,Q,T,Z
B	LONE STAR STEEL COMPANY FORT COLLINS	CO	80521			
0496	LUKENS STEEL COMPANY COATESVILLE	PA	19320		BE	I,K,L,W
0500	MADISON WIRE COMPANY BUFFALO	NY	14220			
0504	MAGNA CORPORATION FLOWOOD	MS	39208		E	

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IRON AND STEEL PLANT INVENTORY

REF/PLT	COMPANY OR PLANT NAME CITY	STATE	ZIP	FORMER REF/PLT	GROUP	SUBCATEGORIES
A	MISSISSIPPI STEEL DIVISION FLOWOOD	MS	39208		B	I,L
0508	MARATHON MANUFACTURING COMPANY HOUSTON	TX	77002		E	
A	MARATHON LETOURNEAU COMPANY LONGVIEW	TX	75601		D	I
B	MARATHON STEEL COMPANY PHOENIX	AZ	85005			
C	ROLLING MILL DIVISION TEMPE	AZ	85282		D	I
0512	MARKIN TUBING INC. WYOMING	NY	14591			
0516	MARYLAND SPECIALTY WIRE, INC. COCKEYSVILLE	MD	21030			
0520	MCCONWAY AND TORLEY CORPORATION PITTSBURGH	PA	15201		DE	I
0524	MCINNES STEEL COMPANY CORRY	PA	16407			
0528	MCLOUTH STEEL CORPORATION DETROIT	MI	48209		CE	S,X,Z
A	TRENTON PLANT TRENTON	MI	48183		A	D,F,J,L,M,O,Q
B	GIBRALTAR PLANT GIBRALTAR	MI	48173		C	R,S
0532	MEAD CORPORATION DAYTON	OH	45402			
B	CHATTANOOGA DIVISION CHATTANOOGA	TN	37401			
0536	MERCER ALLOYS CORPORATION GREENVILLE	PA	16125			
0538	MERCIER CORPORATION BIRMINGHAM	MI	48001			
A	ERIE COKE AND CHEMICAL COMPANY FAIRPORT HARBOR	OH	44077			
0540	MERIDIAN INDUSTRIES, INC. SOUTHFIELD	MI	48075			
A	FORMED TUBES, INC. STURGIS	MI	49091			
B	FORMED TUBES, INC. HALEYVILLE	AL	35565			
C	FORMED TUBES, INC. ALBION	IN	46701			

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IRON AND STEEL PLANT INVENTORY

REF/PLT	COMPANY OR PLANT NAME CITY	STATE	ZIP	FORMER REF/PLT	GROUP	SUBCATEGORIES
0544	MESTA MACHINE COMPANY PITTSBURGH	PA	15230		E	
A	MESTA MACHINE COMPANY PITTSBURGH	PA	15230		B	H,I
B	MESTA MACHINE COMPANY NEW CASTLE	PA	16101			
0548	SEE 0678					
A	SEE 0678A					
B	SEE 0678B					
C	SEE 0678C					
D	SEE 0678D					
E	SEE 0678E					
0552	MID-AMERICA STEEL CORPORATION CLEVELAND	OH	44127			
0556	MID-WEST WIRE COMPANY CLEVELAND	OH	44104			
0560	MINNEAPOLIS ELEC. STEEL CASTINGS CO. MINNEAPOLIS	MN	55421		DE	I
0564	MISSOURI ROLLING MILL CORPORATION ST. LOUIS	MO	63143			
0568	MOLTRUP STEEL PRODUCTS COMPANY BEAVER FALLS	PA	15010			
0572	MSL INDUSTRIES, INC. PIQUA	OH	45356			
A	MIAMI INDUSTRIES, DIVISION PIQUA	OH	45356			
0576	NATIONAL FORGE COMPANY IRVINE	PA	16329		BE	I,K
A	ERIE DIVISION ERIE	PA	16512		B	I,K
0580	NATIONAL STANDARD COMPANY NILES	MI	49120		CE	Q,R,W,Y,Z
A	WOVEN PRODUCTS DIVISION CORBIN	KY	40701		C	R,T,Z
[illegible]	MT. J[illegible]NT MT. JOY	PA	17552		C	R,Z
C	ATHENIA STEEL DIVISION CLIFTON	NJ	07015		C	Q,R,S

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IRON AND STEEL PLANT INVENTORY

REF/PLT	COMPANY OR PLANT NAME CITY	STATE	ZIP	FORMER REF/PLT	GROUP	SUBCATEGORIES
D	COLUMBIANA PLANT COLUMBIANA	AL	35051		C	R,Z
E	AKRON PLANT AKRON	OH	44310		C	R,Z
F	LOS ANGELES PLANT LOS ANGELES	CA	90001		C	R
G	WORCESTER WIRE DIVISION WORCESTER	MA	01603		C	T,W,Z
0584	NATIONAL STEEL PITTSBURGH	PA	15219		E	
A	GREAT LAKES STEEL DIVISION DETROIT	MI	48229		B	F,I,M,R,S
B	GREAT LAKES STEEL DIVISION DETROIT	MI	48229		A	A,C,D,O
C	GRANITE CITY STEEL DIVISION GRANITE CITY	IL	62040		A	A,C,D,G,M,O,Q,R,S,T
D	THE HANNA FURNACE CORPORATION BUFFALO	NY	14240		D	D
E	MIDWEST STEEL DIVISION PORTAGE	IN	46368		C	Q,S,T,Z
F	WEIRTON STEEL WEIRTON	WV	26062		A	A,C,D,G,K,L,M,N,O,R,S, T,Z
G	STEUBENVILLE PLANT STEUBENVILLE	OH	43952			
H	NATIONAL PIPE AND TUBE LIBERTY	TX	77575		C	P
0588	NAYLOR PIPE COMPANY CHICAGO	IL	60619			
0592	NEW ENGLAND HIGH CARBON WIRE CORPORATION MILLBURY	MA	01527			
0596	NEW JERSEY STEEL AND STRUCTURAL CORP. SAYREVILLE	NJ	08872		BE	I,L
0600	NEWMAN-CROSBY STEEL, INC. PAWTUCKET	RI	02861			
0604	NEWPORT NEWS SHIP BLDG. AND DRYDOCK CO. NEWPORT NEWS	VA	23607			
0608	NORTH STAR STEEL COMPANY ST. PAUL	MN	55165		E	
A	WILTON PLANT WILTON	IA	52778		B	I,L
0612	NORTHWESTERN STEEL AND WIRE CO. STERLING	IL	61081		BE	I,M,N,O,R,T
0616	NO. WEST STEEL RLLNG. MILLS, INC. SEATTLE	WA	98107		E	
A	KENT PLANT KENT	WA	98031		D	I

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REF/PLT	COMPANY OR PLANT NAME CITY	STATE	ZIP	FORMER REF/PLT	GROUP	SUBCATEGORIES
0620	NUCOR CORPORATION CHARLOTTE	NC	28211		E	
A	NUCOR STEEL DARLINGTON	SC	29532		B	I,L
B	NUCOR STEEL NORFOLK	NC	68701		B	I,L
C	NUCOR STEEL JEWETT	TX	75846		B	I,L
0624	GILMORE STEEL CORPORATION PORTLAND	OR	97208		E	
A	OREGON STEEL MILLS DIVISION PORTLAND	OR	97209			
B	RIVERGATE PLANT PORTLAND	OR	97203		D	I
0628	OWEN ELECTRIC STEEL OF SOUTH CAROLINA COLUMBIA	SC	29202		E	
A	OWEN ELEC. STEEL OF SO. CAROLINA CAYCE	SC	29033		D	I
0632	PACIFIC STATES STEEL CORPORATION UNION CITY	CA	94587			
0636	PACIFIC TUBE COMPANY LOS ANGELES	CA	90040		CE	P,Q,W,Z
0640	PENN-DIXIE STEEL COMPANY KOKOMO	IN	46901		BE	I,M,N,Q,T
A	PENN-DIXIE STEEL COMPANY JOLIET	IL	60434			
B	ENTERPRISE WIRE COMPANY BLUE ISLAND	IL	60406			
C	HAUSMAN CORPORATION KOKOMO	IN	46901			
D	HAUSMAN CORPORATION DENVER	CO	80203			
E	CENTERVILLE DIVISION CENTERVILLE	IA	52544		D	I
0644	PETTIBONE CORPORATION CHICAGO	IL	60651			
0648	PHILADELPHIA STEEL AND WIRE COMPANY PHILADELPHIA	PA	19154			
0652	PHOENIX STEEL CORPORATION CLAYMONT	DE	19703		BE	I,L
A	PHOENIX STEEL CORPORATION PHOENIXVILLE	PA	19460		C	M,N,P

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IRON AND STEEL PLANT INVENTORY

REF	PLT	COMPANY OR PLANT NAME CITY	STATE	ZIP	FORMER REF/PLT	GROUP	SUBCATEGORIES
0656		PICKANDS MATHER AND COMPANY CLEVELAND	OH	44114		E	
	A	MILWAUKEE SOLVAY COKE COMPANY MILWAUKEE	WI	53204		D	A
0660		PIPER INDUSTRIES INC. MEMPHIS	TN	38113			
	A	PIPER INDUSTRIES INC. ST. LOUIS	MO	63155			
	B	PIPER INDUSTRIES INC. GREENVILLE	MS	38701			
0664		PITTSBURGH TUBE COMPANY MUNACA	PA	15061			
	A	PITTSBURGH INTERNATIONAL CORPORATION FAIRBURY	IL	61739			
0668		PORTEC, INC. OAK BROOK	IL	60521			
	A	TROY PLANT TROY	NY	12180			
	B	FORGINGS DIVISION CANTON	OH	44701			
	C	MEMPHIS PLANT MEMPHIS	TN	38128			
0672		CONNORS STEEL COMPANY BIRMINGHAM	AL	35212		E	
	A	CONNERS STEEL DIVISION BIRMINGHAM	AL	35212		B	I,L,N
	B	WEST VIRGINIA WORKS HUNTINGTON	WV	25706		B	I,L,M,N
0674		PLYMOUTH TUBE COMPANY WINFIELD	IL	60190	0884	E	
	A	ELLWOOD IVINS PLANT HORSHAM	PA	19044	0884A		
	B	PLYMOUTH TUBE DIVISION WINFIELD	IL	60190	0884B		
	C	WINAMAC PLANT WINAMAC	IN	46996	0884C	C	P,Q
	D	STREATOR PLANT STREATOR	IL	61364	0884D	C	Q
	E	PLYMOUTH TUBE DIVISION DUNKIRK	NY	14048	0884E	C	P,W
	F	PLYMOUTH TUBE DIVISION HORSHAM	PA	19044	0884F	C	W
	G	BIRMINGHAM PLANT PINSON	AL	35126	0884G	C	Q
	H	WEST MONROE PLANT WEST MONROE	LA	71291	0884H	C	P

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IRON AND STEEL PLANT INVENTORY

REF/PLT	COMPANY OR PLANT NAME CITY	STATE	ZIP	FORMER REF/PLT	GROUP	SUBCATEGORIES
0676	PREDCO INC. PENNSAUKEN	NJ	08110			
A	PRECISION STEEL DIVISION PENNSAUKEN	NJ	08110			
B	SOUTHERN PRECISION STEEL COMPANY GULFPORT	MS	39501			
C	COMPRESSED STEEL SHAFTING COMPANY, INC. READVILLE	MA	02136			
0678	QUANEX CORPORATION HOUSTON	TX	77056	0548	CE	P
A	GULF STATES TUBE CORPORATION DIV. ROSENBERG	TX	77471	0548A	C	P,W,Z
B	THE STANDARD TUBE COMPANY DETROIT	MI	48239	0548B	C	P,Q,W,Z
C	THE STANDARD TUBE COMPANY SHELBY	OH	44875	0548C	C	P
D	MAC STEEL COMPANY, DIVISION JACKSON	MI	48201	0548D	B	I,L
E	US BROACH AND MACHINE COMPANY DETROIT	MI	48234	0548E		
0680	RAMCO STEEL INC. BUFFALO	NY	14240			
0684	REPUBLIC STEEL CLEVELAND	OH	44101		E	
*	YOUNGSTOWN MANUFACTURING YOUNGSTOWN	OH	44545		C	Z
A	YOUNGSTOWN YOUNGSTOWN	OH	44501		A	A,D,M,N,P,T
B	WARREN WARREN	OH	44181		A	A,C,D,F,M,O,R,S,T,U
C	NILES NILES	OH	44446		C	Q,S,Z
D	MASSILLON MASSILLON	OH	44646		A	A,M,N,Q,S,W,X
E	CANTON SOUTH CANTON	OH	44706		B	I,K,L,M,N,Q
F	CLEVELAND DISTRICT CLEVELAND	OH	44127		A	A,D,F,H,M,N,O,R,S
G	BUFFALO BUFFALO	NY	14220		A	D,F,M,N,Q
H	CHICAGO DISTRICT CHICAGO	IL	60617		A	A,D,H,I,K,M,N,P,Q
I	SOUTHERN DISTRICT GADSDEN	AL	35901		A	A,C,D,F,M,O,R,S,T
J	THOMAS WORKS BIRMINGHAM	AL	35202		D	A
K	STEEL AND TUBE DIVISION CLEVELAND	OH	44108		C	P,Q,W

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REF/PLT	COMPANY OR PLANT NAME CITY	STATE	ZIP	FORMER REF/PLT	GROUP	SUBCATEGORIES
L	STEEL AND TUBE DIVISION ELYRIA	OH	44035		C	P
M	STEEL AND TUBE DIVISION FERNDALE	MI	48220		C	P
N	STEEL AND TUBE DIVISION BROOKLYN	NY	11237		C	P,Q
O	STEEL AND TUBE DIVISION COUNCE	TN	38326		C	P
P	UNION DRAWN DIVISION MASSILLON	OH	44646		C	Q,W
Q	UNION DRAWN DIVISION BEAVER FALLS	PA	15010		C	Q
R	UNION DRAWN DIVISION GARY	IN	46401			
S	UNION DRAWN DIVISION EAST HARTFORD	CT	06108			
T	UNION DRAWN DIVISION LOS ANGELES	CA	90052			
U	A. FINKL AND SONS COMPANY CHICAGO	IL	60614		B	I,K
V	CANTON CANTON	OH			C	O,Q,W,X
W	GEORGIA TUBING CEDAR SPRINGS	GA	31732		C	P
X	INDUSTRIAL PRODUCTS DIVISION CANTON	OH	44705		C	Z
Y	DRAINAGE PRODUCTS DIVISION CANTON	OH	44705		C	Q,T,Z
Z	NILES DOOR PLANT NILES	OH	44446		C	Z
0688	REVERE COPPER AND BRASS, INC. NEW YORK	NY	10016			
A	ROME MANUFACTURING COMPANY DIVISION ROME	NY	13440			
0692	RMI COMPANY NILES	OH	44446			
A	RMI COMPANY ASHTABULA	OH	44004			
0696	ROBLIN INDUSTRIES, INC BUFFALO	NY	14202		E	
A	ROBLIN STEEL COMPANY DUNKIRK	NY	14048		B	I,K,L
B	ROBLIN STEEL COMPANY NORTH TONAWANDA	NY	14120			
0700	ROME STRIP STEEL COMPANY ROME	NY	13440		CE	S
0704	ROSS-MEEHAN FOUNDRIES CHATTANOOGA	TN	37401			

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REF/PLT	COMPANY OR PLANT NAME CITY	STATE	ZIP	FORMER REF/PLT	GROUP	SUBCATEGORIES
0708	FOSS STEEL WORKS, INC. AMITE	LA	70422			
0712	SANDVIK STEEL INC. FAIR LAWN	NJ	07410			
A	SCRANTON WORKS CLARKS SUMMIT	PA	18501			
B	BENTON HARBOR WORKS BENTON HARBOR	MI	49022			
0716	SENECA STEEL SERVICE BUFFALO	NY	14217			
0720	SENECA WIRE AND MANUFACTURING COMPANY FOSTORIA	OH	44830			
0724	SHARON STEEL CORPORATION SHARON	PA	16146		E	
A	STEEL DIVISION SHARON	PA	16146		B	D,G,I,K,R,S,T,W,X
B	UNION STEEL CORPORATION UNION	NJ	07083			
C	DEARBORN DIVISION DETROIT	MI	48228			
D	BRAINARD STRAPPING DIVISION WARREN	OH	44482			
E	DAMASCUS TUBE DIVISION GREENVILLE	PA	16125			
F	FAIRMONT COKE WORKS FAIRMONT	WV	26554		D	A
G	CARPENTERTOWN COAL AND COKE COMPANY TEMPLETON	PA	16259			
H	MACOMBER INC. CANTON	OH	44711			
0728	SHARON TUBE COMPANY SHARON	PA	16146		CE	P,Q,T,Z
0732	SHENANGO INC. PITTSBURGH	PA	15222		E	
A	NEVILLE ISLAND PLANT PITTSBURGH	PA	15225		A	A,D
B	BUFFALO PLANT BUFFALO	NY	14240			
C	SHARPSVILLE PLANT SHARPSVILLE	PA	16150			
0736	SIMONDS STL DV OF WALLACE MURRAY NEW YORK	NY	10017		DE	I
0740	SOULE STEEL COMPANY SAN FRANCISCO	CA	94124		E	
A	STEEL MILL OPERATIONS CARSON	CA	90745		B	I,L

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IRON AND STEEL PLANT INVENTORY

REF/PLT	COMPANY OR PLANT NAME CITY	STATE	ZIP	FORMER REF/PLT	GROUP	SUBCATEGORIES
0744	SOUTHERN FABRICATING COMPANY					
	SHEFFIELD	AL	35660			
A	DIXIE TUBE AND STEEL, INC.					
	DOTHAN	AL	36301			
0748	SOUTHWESTERN PIPE, INC.					
	HOUSTON	TX	77001			
A	SOUTHWESTERN PIPE, INC.					
	BOSSIER CITY	LA	71010			
0752	STANDARD FORGINGS CORPORATION					
	EAST CHICAGO	IN	46312			
0756	STANDARD STEEL SPECIALTY COMPANY					
	BEAVER FALLS	PA	15010			
A	SUPERIOR DRAWN STEEL COMPANY					
	MONACA	PA	15061			
0760	THE STANLEY STEEL DIVISION				CE	O,S,Z
	NEW BRITAIN	CT	06050			
A	THE STANLEY STEEL DIVISION					
	NEW BRITAIN	CT	06053			
0764	SEE 0226					
A	SEE 0226A					
0768	STUPP BROTHERS BRIDGE AND IRON COMPANY					
	ST. LOUIS	MO	63125			
A	STUPP CORPORATION					
	BATON ROUGE	LA	70821			
B	MENGEL ROAD PLANT					
	BATON ROUGE	LA	70821			
C	THOMAS ROAD PLANT					
	BATON ROUGE	LA	70821			
0772	SUPERIOR TUBE COMPANY					
	NORRISTOWN	PA	19404			
0776	TELEDYNE VASCO				E	
	LATROBE	PA	15650			
A	TELEDYNE ALLVAC					
	MONROE	NC	28110			
B	TELEDYNE COLUMBIA - SUMMERILL					
	PITTSBURGH	PA	15230			
C	SCOTTDALE PLANT				C	W,Z
	SCOTTDALE	PA	15683			
D	CARNEGIE PLANT				C	O,Z
	CARNEGIE	PA	15106			
E	TELEDYNE OHIO STEEL COMPANY				B	I,K
	LIMA	OH	45802			

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REF/PLT	COMPANY OR PLANT NAME CITY	STATE	ZIP	FORMER REF/PLT	GROUP	SUBCATEGORIES
F	TELEDYNE PITTSBURGH TOOL STEEL MONACA	PA	15061		C	W
G	ROD AND WIRE DEPARTMENT LATROBE	PA	15650		B	I,N,W,X,Z
H	COLONIAL PLANT MONACA	PA	15061		C	N,O,W,X
I	TELEDYNE SURFACE ENGINEERING PITTSBURGH	PA	15206			
J	TELEDYNE VASCO - CK COMPANY SOUTH BOSTON	VA	24592		C	W
0780	TENNESSEE FORGING STEEL ROANOKE	VA	24015		DE	I,L
A	NEWPORT DIVISION NEWPORT	AR	72112			
B	JONES AND MCKNIGHT CORPORATION CHICAGO	IL	60623			
C	KANKAKEE ELECTRICAL STEEL WORKS KANKAKEE	IL	60901			
0784	TEXAS STEEL COMPANY FT. WORTH	TX	76110		DE	I
0788	THOMAS STEEL STRIP CORPORATION WARREN	OH	44485			
0792	THOMPSON STEEL COMPANY, INC. BRAINTREE	MA	02184		E	
A	THOMPSON STEEL COMPANY, INC. WORCESTER	MA	01603		C	N,T,W
B	THOMPSON STEEL COMPANY, INC. CHICAGO	IL	60131		C	Q,S,T
C	THOMPSON STEEL COMPANY, INC. SPARROWS POINT	MD	21219		C	Q,S
0796	THE TIMKEN COMPANY CANTON	OH	44706		E	
A	GAMBRINUS PLANT CANTON	OH	44706		B	I,K,L,M,N,P,Q,W,Z
B	WOOSTER PLANT WOOSTER	OH	44691		C	P,Q
C	LATROBE STEEL COMPANY LATROBE	PA	15650		B	I,K
0800	TIPPINS MACHINERY COMPANY, INC. ETNA	PA	15223			
A	TIPPINS MACHINERY COMPANY, INC. LAWRENCEVILLE	PA	15201			
0804	TITANIUM METALS CORP. OF AMERICA TORONTO	OH	43964		E	
A	STANDARD STEEL DIVISION BURNHAM	PA	17009		B	I,K
B	LATROBE FORGE AND SPRING LATROBE	PA	15650		B	I,K

APPENDIX B

IRON AND STEEL PLANT INVENTORY

REF/PLT	COMPANY OR PLANT NAME CITY	STATE	ZIP	FORMER REF/PLT	GROUP	SUBCATEGORIES
0808	TOLEDO PICKLING AND STEEL SERVICE TOLEDO	OH	43607			
0810	TONAWANDA COKE COMPANY HARRIET	NY		0024D	D	A
0812	TONAWANDA IRON DIVISION NORTH TONAWANDA	NY	14120			
0816	TOWNSEND COMPANY BEAVER FALLS	PA	15010			
A	TOWNSEND PLANT NEW BRIGHTON	PA	15066			
0820	TREDEGAR COMPANY RICHMOND	VA	23211			
0824	TUBE METHODS, INC. BRIDGEPORT	PA	19405			
0828	TULL, J.M. INDUSTRIES, INC. ATLANTA	GA	30301			
A	TAMPCO DIVISION NORCROSS	GA	30091			
0832	ULBRICH STAINLESS STEELS OF SPEC. METALS WALLINGFORD	CN	06492			
0836	UNARCO-LEAVITT TUBE DIVISION CHICAGO	IL	60643			
0840	UNION ELECTRIC STEEL CORPORATION PITTSBURGH	PA	15106		E	
A	UNION ELECTRIC STEEL CORPORATION CARNEGIE	PA	15106			
B	HARMON CREEK BURGETTSTOWN	PA	15021		B	I,K
C	HARMON CREEK VALPARAISO	IN	46383			
0844	UNION SPECIALTY STEEL CASTING CORP. VERONA	PA	15147			
0848	SEE 0426					
0852	UNITED STATES STEEL CORPORATION PITTSBURGH	PA	15230			
A	UNITED STATES STEEL CORPORATION NEW YORK	NY	10022			
0856	UNITED STATES STEEL - EASTERN PITTSBURGH	PA	15219		E	
A	CLAIRTON WORKS CLAIRTON	PA	15025		A	A,D,H
B	EDGAR THOMSON WORKS BRADDOCK	PA	15104		A	D,F

APPENDIX B

IRON AND STEEL PLANT INVENTORY

REF/PLT	COMPANY OR PLANT NAME CITY	STATE	ZIP	FORMER REF/PLT	GROUP	SUBCATEGORIES
C	CHRISTY PARK MCKEESPORT	PA	15132		C	P
D	IRVIN WORKS DRAVOSBURG	PA	15034		C	O,Q,S,T,U,Z
E	VANDERGRIFT VANDERGRIFT	PA	15690		C	O,Q,S,W,X,Z
F	FAIRLESS WORKS FAIRLESS HILLS	PA	19030		A	A,C,D,H,J,K,L,M,N,O,P, Q,R,S,T,Z
G	FAIRLESS WORKS TRENTON	NJ	08608			
H	HOMESTEAD WORKS HOMESTEAD	PA	15120		B	H,K,M,N,O,W
I	HOMESTEAD WORKS HOMESTEAD	PA	15120		D	D
J	HOMESTEAD WORKS HOMESTEAD	PA	15120		D	C
K	HOMESTEAD WORKS HOMESTEAD	PA	15120		C	N
L	JOHNSTOWN PLANT JOHNSTOWN	PA	15902			
M	CANTON PLANT CANTON	OH	44706			
N	LORAIN PLANT LORAIN	OH	44055		A	A,C,D,F,M,N,P,Q,T,Z
O	CENTRAL FURNACES PLANT CLEVELAND	OH	44115		D	D
P	CUYAHOGA PLANT CUYAHOGA HEIGHTS	OH	44125		C	N,O,Q,R,S,T
Q	NATIONAL PLANT MCKEESPORT	PA	15132		A	C,D,M,N,P,Q,Z
R	DUQUESNE PLANT DUQUESNE	PA	15110		A	D,G,I,K,M,N,O
S	NEW HAVEN WORKS NEW HAVEN	CT	06507		C	Q,R,T
T	YOUNGSTOWN WORKS YOUNGSTOWN	OH	44509		A	C,D,H,M,Q
U	MACDONALD WORKS MACDONALD	OH	44437		C	N,O,Q
0860	UNITED STATES STEEL - CENTRAL PITTSBURGH	PA	15230		E	
A	DULUTH PLANT DULUTH	MN	55808		D	A
B	GARY WORKS GARY	IN	46401		A	A,C,D,G,H,L,M,N
C	GARY TUBE WORKS GARY	IN	46401			
D	ELLWOOD PLANT ELLWOOD CITY	PA	16117			
F	JOLIET PLANT JOLIET	IL	60432		C	N,Q,R,T,W

APPENDIX B

IRON AND STEEL PLANT INVENTORY

REF/PLT	COMPANY OR PLANT NAME CITY	STATE	ZIP	FORMER REF/PLT	GROUP	SUBCATEGORIES
G	WAUKEGAN PLANT WAUKEGAN	IL	60085		C	Q,T
H	SOUTH WORKS CHICAGO	IL	60617		A	C,D,G,J,K,L,M,N,O
0864	UNITED STATES STEEL - WESTERN PITTSBURGH	PA	15230		E	
A	GENEVA WORKS PROVO	UT	84601		A	A,C,D,H,M,N,O,P
B	PITTSBURG WORKS PITTSBURG	CA	94546		C	M,Q,R,S,T,Z
C	TORRANCE WORKS TORRANCE	CA	90501		B	H,L,M,N
0868	UNITED STATES STEEL - SOUTHERN PITTSBURGH	PA	15230		E	
A	FAIRFIELD WORKS FAIRFIELD	AL	35064		A	A,C,D,F,H,M,O,Q,R,S,T, Z
B	TEXAS WORKS BAYTOWN	TX	77520		B	J,K,L,O,P
C	AMERICAN BRIDGE DIVISION ORANGE	TX	77630			
0872	VALLEY MOULD AND IRON HUBBARD	OH	44425			
A	CHICAGO PLANT CHICAGO	IL	60617			
B	CLEVELAND PLANT CLEVELAND	OH	44105			
0876	VALMONT INDUSTRIES, INC. VALLEY	NB	68064			
0880	VAN DORN HEAT TREATING COMPANY CLEVELAND	OH	44101			
A	HEAT TREATING DIVISION MCKEES ROCKS	PA	15136			
0884	SEE 0674					
A	SEE 0674A					
B	SEE 0674B					
C	SEE 0674C					
D	SEE 0674D					
E	SEE 0674E					
F	SEE 0674F					
G	SEE 0674G					
H	SEE 0674H					

APPENDIX B

IRON AND STEEL PLANT INVENTORY

REF/PLT	COMPANY OR PLANT NAME CITY	STATE	ZIP	FORMER REF/PLT	GROUP	SUBCATEGORIES
0888	VULCAN INC. LATROBE	PA	15650			
A	VULCAN MOULD AND IRON COMPANY LATROBE	PA	15650			
B	VULCAN MOULD AND IRON COMPANY LANSING	IL	60438			
C	VULCAN MOULD AND IRON COMPANY TRENTON	MI	48183			
0892	WALKER MANUFACTURING COMPANY RACINE	WI	53402			
A	ABERDEEN PLANT ABERDEEN	MS	39730			
B	ARDEN PLANT ARDEN	NC	28704			
C	GREENVILLE PLANT GREENVILLE	TX	75401			
D	HARRISONBURG PLANT HARRISONBURG	VA	22801			
E	JACKSON PLANT JACKSON	MI	49201			
F	NEWARK PLANT NEWARK	OH	43055			
G	SEWARD PLANT SEWARD	NB	58434			
0894	WALKER STEEL AND WIRE COMPANY FERNDALE	MI				
0896	WASHBURN WIRE COMPANY EAST PROVIDENCE	RI	02916		BE	I,K
A	WASHBURN WIRE COMPANY NEW YORK	NY	10035			
0900	WASHINGTON STEEL CORPORATION WASHINGTON	PA	15301		E	
A	FITCH WORKS HOUSTON	PA	15342		D	I
B	CALSTRIP STEEL COMPANY LOS ANGELES	CA	90022			
0904	WELDED TUBES, INC. ORWELL	OH	44076			
0908	WELDED TUBE COMPANY OF AMERICA PHILADELPHIA	PA	19148		CE	P
A	WELDED TUBE COMPANY OF AMERICA CHICAGO	IL	60633		C	P
0912	WESTERN COLD DRAWN STEEL DIVISION ELYRIA	OH	44035			
A	WESTERN COLD DRAWN STEEL DIVISION GARY	IN	46401			

APPENDIX B

IRON AND STEEL PLANT INVENTORY

REF/PLT	COMPANY OR PLANT NAME CITY	STATE	ZIP	FORMER REF/PLT	GROUP	SUBCATEGORIES
0916	WHEATLAND TUBE COMPANY PHILADELPHIA	PA	19106		E	
A	WHEATLAND STEEL PRODUCTS WHEATLAND	PA	16161		C	P,Q,T,Z
0920	WHEELING-PITTSBURGH STEEL CORP. PITTSBURGH	PA	15230		E	
A	STEUBENVILLE NORTH PLANT STEUBENVILLE	OH	43952		A	D,M,R,S
B	MONESSEN PLANT MONESSEN	PA	15062		A	A,C,D,F,M,N
C	ALLENPORT ALLENPORT	PA	15412		C	O,P,R,S
D	BENWOOD BENWOOD	WV	26031		C	P,Q,T
E	MARTINS FERRY MARTINS FERRY	OH	43935		C	T
F	STEUBENVILLE EAST FOLLANSBEE	WV	26037		A	A,C,U
G	YORKVILLE PLANT YORKVILLE	OH	43971		C	R,S,Z
H	SEE 0430					
I	SEE 0430A					
J	SEE 0430B					
K	WHEELING CORRUGATION COMPANY WHEELING	WV	26003			
L	BEECH BOTTOM PLANT BEECH BOTTOM	WV	26030		C	Z
M	LABELLE PLANT WHEELING	WV	26003			
N	STEUBENVILLE SOUTH PLANT MINGO JUNCTION	OH	43938		A	D,G,M,O
U	CANFIELD PLANT CANFIELD	OH	44406		C	Z
0924	WHITTAKER CORPORATION DETROIT	MI	48234			
A	WHITTAKER STRIP STEEL DIVISION DETROIT	MI	48234			
0928	WILSON STEEL AND WIRE COMPANY CHICAGO	IL	60609			
0932	WIRE ROPE CORPORATION OF AMERICA ST. JOSEPH	MO	64502			
0936	WIRE SALES COMPANY CHICAGO	IL	60632			

APPENDIX B

IRON AND STEEL PLANT INVENTORY

REF/PLT	COMPANY OR PLANT NAME CITY	STATE	ZIP	FORMER REF/PLT	GROUP	SUBCATEGORIES
0940	WITTEMAN STEEL MILLS FONTANA	CA	92335		BE	I,M
0944	WRIGHT STEEL AND WIRE COMPANY WORCESTER	MA	01603			
0946	WSC CORPORATION CHICAGO	IL	60617	C400	E	
A	WISCONSIN STEEL WORKS CHICAGO	IL	60617	C400A	A	A,C,D,F,K,L,M,N,Q
0948	YOUNGSTOWN SHEET AND TUBE CO. YOUNGSTOWN	OH	44501		E	
A	CAMPBELL WORKS STRUTHERS	OH	44471		A	A,C,D,H,M,O,P,Q,R,S,T
B	BRIER HILL WORKS YOUNGSTOWN	OH	44510		A	D,H,M,N,P,Q
C	INDIANA HARBOR WORKS EAST CHICAGO	IN	46312		A	A,C,D,F,H,M,O,P,Q,S,T
D	VAN HUFFEL TUBE CORPORATION WARREN	OH	44481			
E	VAN HUFFEL TUBE CORPORATION GARDNER	MA	01440			
F	CAMPBELL WORKS-STRUTHERS DIVISION STRUTHERS	OH	44471		C	N,W,Z

APPENDIX B

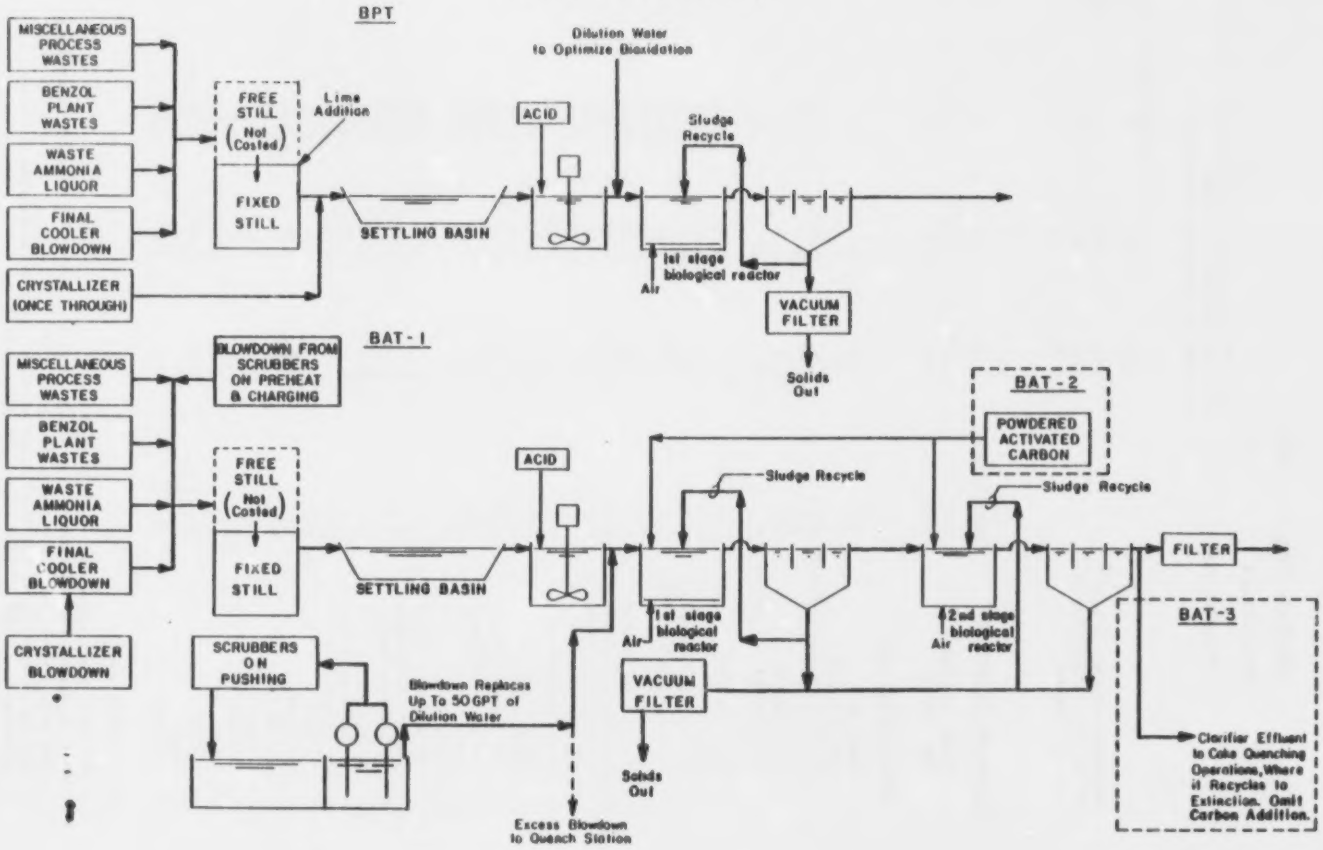
KEY TO SUBCATEGORY CODES

A. By-Product
B. Beehive
C. Sintering
D. Blast Furnace (Iron)
E. Blast Furnace (Ferromanganese)
F. Basic Oxygen Furnace (Semi-Wet)
G. Basic Oxygen Furnace (Wet)
H. Open Hearth Furnace
I. Electric Arc Furnace (Semi-Wet)
J. Electric Arc Furnace (Wet)
K. Vacuum Degassing
L. Continuous Casting
M. Hot Forming - Primary
N. Hot Forming - Section
O. Hot Forming - Flat
P. Pipe and Tube
Q. Sulfuric Acid Pickling
R. Hydrochloric Acid Pickling
S. Cold Rolling
T. Hot Coating - Galvanizing
U. Hot Coating - Terne
V. Miscellaneous Runoffs
W. Combination Acid Pickling
X. Scale Removal - Kolene and Hydride
Y. Wire Pickling and Coating
Z. Alkaline Cleaning

VOLUME I

APPENDIX C

BYPRODUCT COKEMAKING TREATMENT MODELS SUMMARY


BPT
MISCELLANEOUS PROCESS WASTES
BENZOL PLANT WASTES
WASTE AMMONIA LIQUOR
FINAL COOLER BLOWDOWN
CRYSTALLIZER (ONCE THROUGH)
FREE STILL (Not Costed)
FIXED STILL
Lime Addition
SETTLING BASIN
ACID
Dilution Water to Optimize Biaxidation
Sludge Recycle
1st stage biological reactor
Air
VACUUM FILTER
Solids Out
BAT - I
BLOWDOWN FROM SCRUBBERS ON PREHEAT & CHARGING
MISCELLANEOUS PROCESS WASTES
BENZOL PLANT WASTES
WASTE AMMONIA LIQUOR
FINAL COOLER BLOWDOWN
CRYSTALLIZER BLOWDOWN
FREE STILL (Not Costed)
FIXED STILL
SETTLING BASIN
ACID
SCRUBBERS ON PUSHING
Blowdown Replaces Up To 50 GPT of Dilution Water
Excess Blowdown to Quench Station
Sludge Recycle
1st stage biological reactor
Air
VACUUM FILTER
Solids Out
BAT - 2
POWDERED ACTIVATED CARBON
Sludge Recycle
2nd stage biological reactor
Air
FILTER
BAT - 3
Clarifier Effluent to Coke Quenching Operations, Where it Recycles to Extinction. Omit Carbon Addition.

SUBCATEGORY SUMMARY DATA: BASIS 7/1/78 DOLLARS

Subcategory: By-Product Cokemaking

Model Size-TPD : 3600
Oper. Days/Year: 365
Turns/Day : 3

Raw Waste Flows	(MGD)	
Model Plant:	0.605	
59 Active Plants:	36.9	13.9 MGD from direct discharge after treatment 10.1 MGD indirect via POTW 12.9 MGD to quenching operations

	BAT Feed	BAT Alternatives 1	2	3
Investment (Model) $ x 10^{-3}	5718	871	923	653
Annual Cost (Model)(1) $ x 10^{-3}	1782	161.5	407.0	118.7
$/Ton of Product	1.36	0.123	0.310	0.090

	Wastewater Parameters	Raw Waste Loads	BAT Feed	1	2	3
	Flow, gal/ton	168(2)	225(3)	153(4)	153(4)	0
	pH, (Units)	7-10	6-9	6-9	6-9	-
	Concentrations, mg/1					
	Ammonia	600	100	15	15	-
	Oil & Grease	75	10	5	5	-
	Phenolic Compounds(4AAP)	300	0.5	0.025	0.025	-
	Sulfide	150	1.0	0.4	0.3	-
	Thiocyanate	480	2.0	1.0	0.5	-
	Total Suspended Solids	50	80	20	20	-
3	Acrylonitrile	1.2	0.1	0.03	0.01	-
4	Benzene*	35	0.5	0.05	0.05	-
21	2,4,6-Trichlorophenol	0.1	0.02	0.01	0.01	-
22	Parachlorometacresol	0.6	0.05	0.01	0.01	-
23	Chloroform*	0.2	0.2	0.10	0.05	-
34	2,4-Dimethylphenol	5	0.05	0.02	0.01	-
35	2,4-Dinitrotoluene	0.2	0.02	0.01	0.01	-
36	2,6-Dinitrotoluene	0.1	0.02	0.01	0.01	-
38	Ethylbenzene*	3	0.1	0.03	0.02	-
39	Fluoranthene*	0.8	0.1	0.02	0.01	-
54	Isophorone	0.5	0.2	0.02	0.01	-
55	Naphthalene*	30	0.1	0.01	0.01	-
60	4,6-Dinitro-o-cresol	0.12	0.02	0.01	0.01	-
64	Pentachlorophenol	0.12	0.02	0.01	0.01	-
65	Phenol*	275	0.4	0.05	0.01	-
66 through 71						
	Phthalates, Total*	5	1	0.2	0.06	-
72	Benzo(a)anthracene	0.3	0.1	0.01	0.01	-
73	Benzo(a)pyrene*	0.1	0.05	0.02	0.01	-
76	Chrysene*	0.4	0.1	0.05	0.01	-
77	Acenaphthylene*	3.5	0.1	0.03	0.02	-
80	Fluorene*	0.6	0.1	0.02	0.01	-
84	Pyrene*	0.6	0.2	0.04	0.02	-
86	Toluene*	25	0.5	0.05	0.05	-
114	Antimony*	0.2	0.1	0.10	0.10	-
115	Arsenic*	2.0	0.4	0.25	0.25	-
121	Cyanides*	50	5.0	2.5	2.0	-
125	Selenium*	0.2	0.1	0.10	0.10	-
126	Silver	0.1	0.08	0.06	0.05	-
128	Zinc*	0.2	0.1	0.10	0.10	-
131	Xylene*	12	0.2	0.02	0.01	-

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(1) BAT costs are incremental over BAT Feed Costs.
(2) Flow is measured downstream of free stills, and includes 6 GPT of steam condensate from that source. True raw waste flow is 162 GPT.
(3) Flow includes up to 50 GPT of dilution water to optimize conditions for bio-oxidation and 7 GPT of lime slurry and steam condensate.
(4) Flow reduction achieved by recycling barometric condenser wastewater, with 4% blowdown (3 GPT) to treatment. Also, up to 50 GPT of dilution water is replaced with blowdowns from air pollution control scrubbers on preheating, charging or pushing operations. Any excess blowdown flow (from pushing only) is disposed of via quenching.
*: Toxic pollutant found in all raw waste samples analyzed.

SUMMARY OF EFFLUENT LOADINGS (TONS/YEAR) AND TREATMENT COSTS BY-PRODUCT COKEMAKING SUBCATEGORY(1)

	Raw Waste Load	BAT Feed	BAT-1/BCT	BAT-2	BAT-3
Flow (MGD)	36.9	49.0	34.1	34.1	0
Suspended Solids	2,807	5,915	1,037	1,037	-
Oil & Grease	4,211	756	271	259	-
Ammonia, as N	33,690	7,514	861	766	-
Cyanides, Total	2,807	421	171	99.5	-
Phenolic Compounds	16,845	40	3.6	1.7	-
Sulfide	8,423	149	91.4	15.6	-
Thiocyanate	26,951	1,009	647	383	-
Toxic Metals	152	58.2	23.8	22.8	-
Toxic Organics*	6,654	309	37.2	23.2	-

OPTION COSTS
(MILLIONS OF DOLLARS)

Model Plant (3600 TPD)	BAT Feed	BAT-1	BAT-2	BAT-3
Capital	5.72	0.87	0.92	0.65
Annual	1.78	0.16	0.41	0.12
Subcategory (59 Plants)(2)				
Capital	337.48	51.33	54.28	38.35
Annual	105.02	9.44	24.19	7.08

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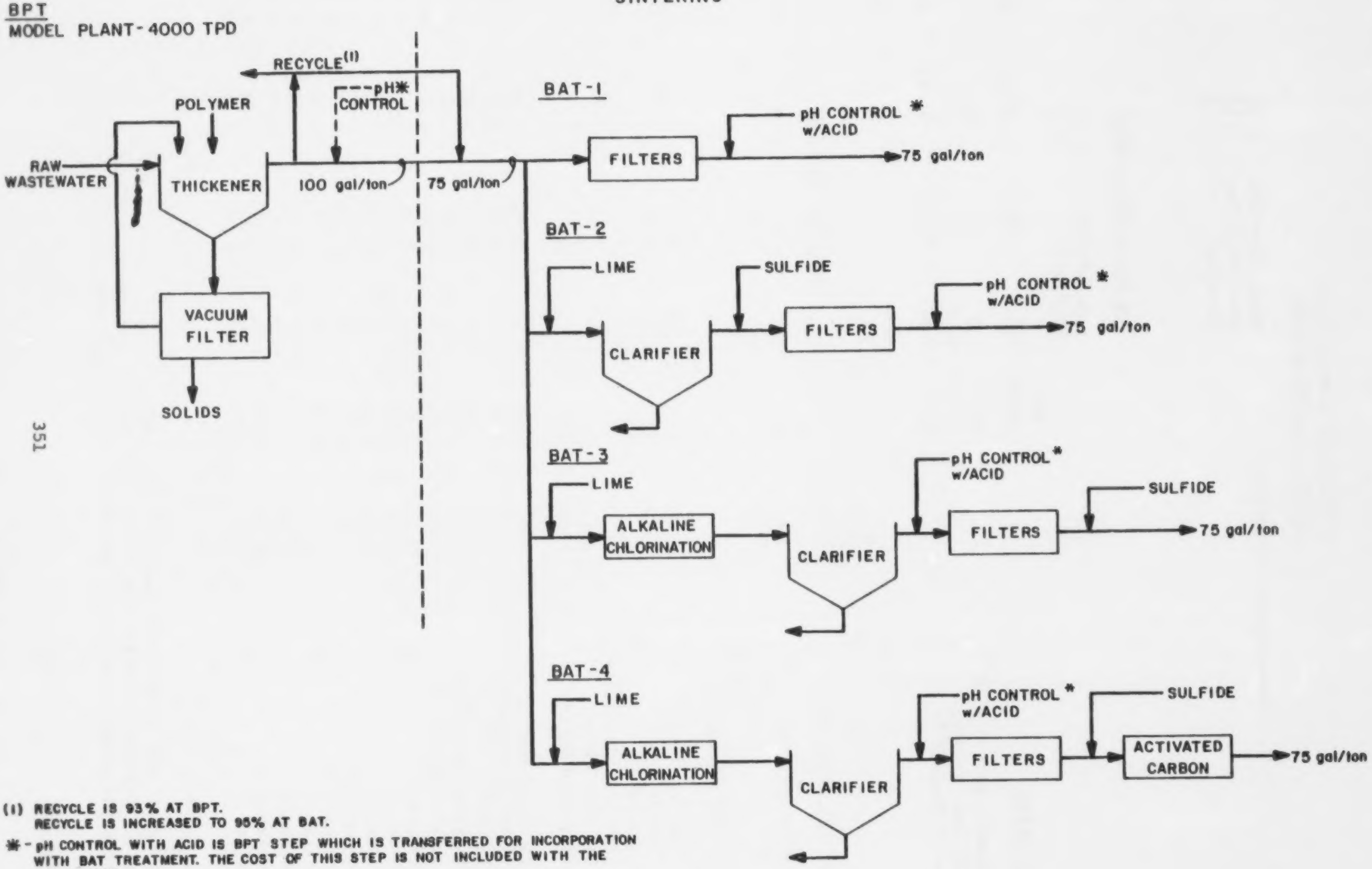
*: Not including phenolic compounds and cyanides, which are listed separately above.

(1) Loads based upon 61 active by-product coke plants:

59 using biological treatment systems
2 using physical-chemical treatment systems

(2) Option costs are shown for the 59 biological treatment systems only. The two physical/chemical treatment systems differ significantly from the model plant.

SINTERING


BPT
MODEL PLANT-4000 TPD
RAW WASTEWATER
POLYMER
THICKENER
VACUUM FILTER
SOLIDS
RECYCLE(1)
pH* CONTROL
100 gal/ton
75 gal/ton
BAT-1
FILTERS
pH CONTROL * w/ACID
75 gal/ton
BAT-2
LIME
CLARIFIER
SULFIDE
FILTERS
pH CONTROL * w/ACID
75 gal/ton
BAT-3
LIME
ALKALINE CHLORINATION
CLARIFIER
pH CONTROL * w/ACID
FILTERS
SULFIDE
75 gal/ton
BAT-4
LIME
ALKALINE CHLORINATION
CLARIFIER
pH CONTROL * w/ACID
FILTERS
SULFIDE
ACTIVATED CARBON
75 gal/ton

(1) RECYCLE IS 93% AT BPT.
RECYCLE IS INCREASED TO 95% AT BAT.

* - pH CONTROL WITH ACID IS BPT STEP WHICH IS TRANSFERRED FOR INCORPORATION WITH BAT TREATMENT. THE COST OF THIS STEP IS NOT INCLUDED WITH THE BAT COSTS.

SUBCATEGORY SUMMARY DATA
BASIS: 7/1/78 DOLLARS

Subcategory: Sintering

Model Size-TPD : 4000
Oper. Days/Year: 365
Turns/Day : 3

Raw Waste Flows (MGD)

Model Plant: 5.84
21 Plants: 122.6

Model Costs	BAT Feed	BAT 1	BAT 2	BAT 3	BAT 4
Investment Cost \$ x 10^{-3}	3843	243	565	631	2535
Annual Cost \$ x 10^{-3}	1774.5	44.6	108.2	123.7	939.8
\$/Ton of Product(1)	1.22	0.031	0.074	0.085	0.644

	Wastewater Parameters	Raw Waste Level(2)	EFFLUENT QUALITY				
	Flow, gal/ton	1460	100	75	75	75	75
	pH	6-12	6-9	6-9	6-9	6-9	6-9
	Concentrations (mg/1)						
	Cyanide, Total	0.20	0.50	0.50	0.50	0.25	0.25
	Phenols(4 AAP)	0.20	2.0	2.0	2.0	0.10	0.05
	Fluoride	6	30	30	10	10	10
	Chlorine (Residual)	-	-	-	-	0.5	0.5
	Oil and Grease	245	10	5	5	5	5
	Suspended Solids	6100	50	15	15	15	15
39	Fluoranthene	0.01	0.10	0.10	0.10	0.10	0.01
59	2,4-Dinitrophenol	0.01	0.05	0.05	0.05	0.025	0.025
65	Phenol*	0.01	0.05	0.05	0.05	0.05	0.05
72	Benzo-a-anthracene	0.01	0.01	0.01	0.01	0.01	0.01
73	Benzo-a-pyrene	0.01	0.01	0.01	0.01	0.01	0.01
76	Chrysene	0.01	0.01	0.01	0.01	0.01	0.01
84	Pyrene*	0.01	0.01	0.01	0.01	0.01	0.01
118	Cadmium*	0.20	0.20	0.10	0.10	0.10	0.10
119	Chromium*	0.70	0.35	0.10	0.10	0.10	0.10
120	Copper*	0.10	0.10	0.10	0.10	0.10	0.10
122	Lead	0.60	0.35	0.10	0.10	0.10	0.10
124	Nickel*	0.50	0.35	0.10	0.10	0.10	0.10
126	Silver*	0.20	0.20	0.10	0.10	0.10	0.10
128	Zinc*	1.00	0.35	0.10	0.10	0.10	0.10

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(1) BAT costs are incremental over BAT feed costs.

(2) Levels reflect the discharge from a once-through wastewater system.

*: Toxic pollutant found in all raw waste samples analyzed.

SUMMARY OF EFFLUENT LOADINGS (TONS/YEAR) AND TREATMENT COSTS
SINTERING SUBCATEGORY

	Raw Waste Load	BAT Feed	BAT-1	BAT-2	BAT-3	BAT-4
Flow (MGD)	122.6	8.4	6.3	6.3	6.3	6.3
TSS	1,138,650	639.3	143.8	143.8	143.8	143.8
Oils	45,730	127.9	47.94	47.94	47.94	47.94
Toxic Metals	616.0	24.29	6.71	6.71	6.71	6.71
Toxic Organics(1)	9.33	1.79	1.34	1.34	1.34	0.48
Fluoride	1,120	383.6	287.7	95.89	95.89	95.89
Cyanide (T)	37.33	6.39	4.79	4.79	2.40	2.40
Phenols	37.33	25.57	19.18	19.18	0.96	0.48

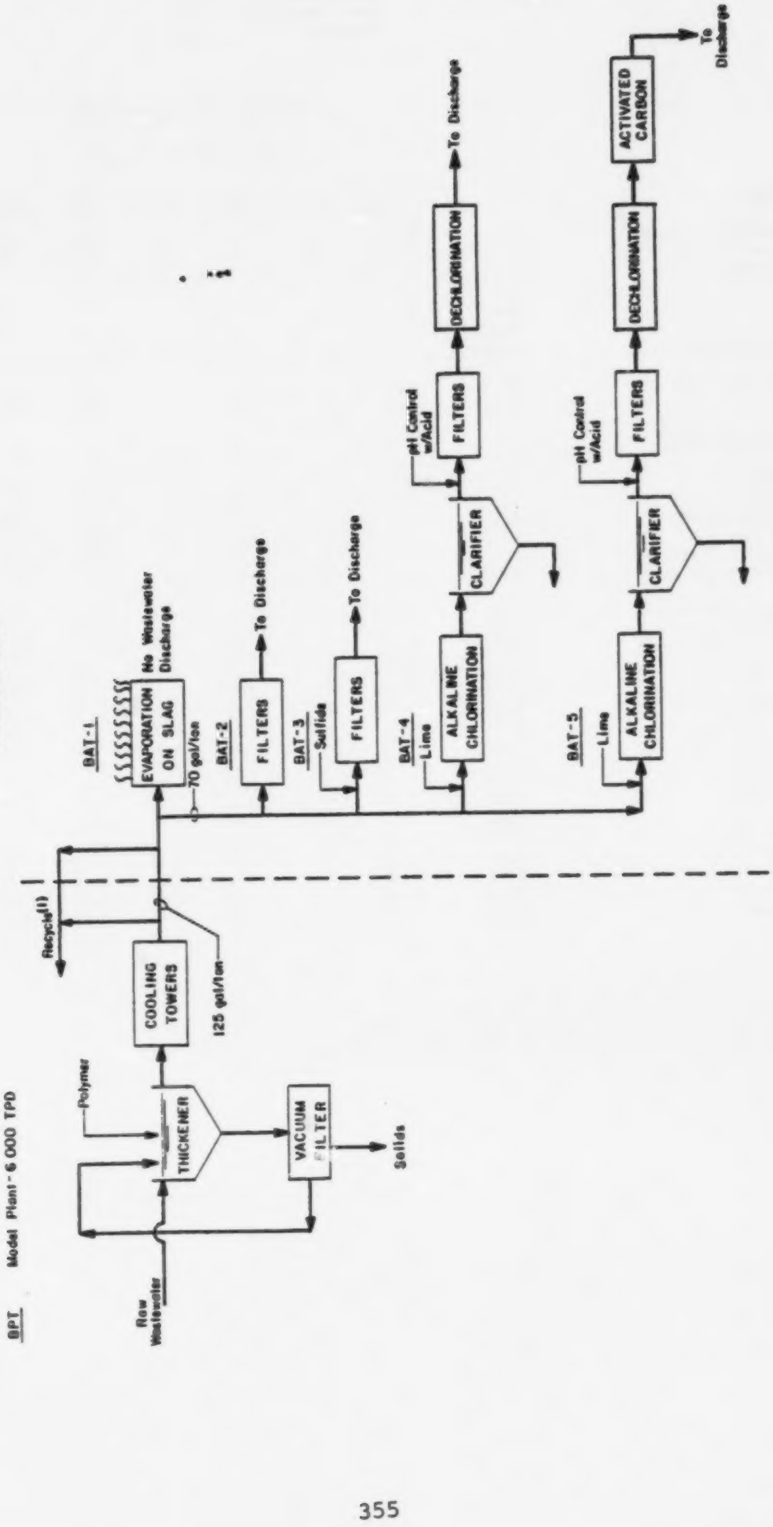
OPTION COSTS
(MILLIONS OF DOLLARS)

	BAT Feed	BAT-1	BAT-2	BAT-3	BAT-4
Model Plant (4000 TPD)					
Investment	3.84	0.18	0.52	0.56	2.46
Annual	1.77	0.033	0.099	0.11	0.92
Subcategory (21 Plants)					
Investment	80.70	3.76	10.90	11.66	51.64
Annual	37.26	0.69	2.07	2.28	19.41

---

(1) Does not include phenols and the individual phenolic compounds.

IRONMAKING


BPT
Model Plant - 6 000 TPD
Raw Wastewater
Polymer
THICKENER
VACUUM FILTER
Solids
COOLING TOWERS
125 gal/ton
Recycle(1)
70 gal/ton
BAT-1
EVAPORATION ON SLAG
No Wastewater Discharge
BAT-2
FILTERS
To Discharge
BAT-3
Sulfide
FILTERS
To Discharge
BAT-4
Lime
ALKALINE CHLORINATION
CLARIFIER
pH Control w/Acid
FILTERS
DECHLORINATION
To Discharge
BAT-5
Lime
ALKALINE CHLORINATION
CLARIFIER
pH Control w/Acid
FILTERS
DECHLORINATION
ACTIVATED CARBON
To Discharge

(1) RECYCLE IS 96% AT BPT.
RECYCLE IS INCREASED TO 98% AT BAT.

SUBCATEGORY SUMMARY DATA
BASIS: 7/1/78 DOLLARS

Subcategory: Ironmaking

Model Size-TPD : 6000
Oper. Days/Year: 365
Turns/Day : 3

Raw Waste Flows (MGD)

Model Plant: 19.2
54 Plants: 1036.8

Model Costs	BAT Feed	BAT 1	BAT 2	BAT 3	BAT 4	BAT 5
Investment Cost $ x 10^{-3}	9542	213	326	394	820	3001
Annual Cost $ x 10^{-3}	1764.4	40.4	59.7	75.2	165.0	1096.5
$/Ton of Product(1)	0.806	0.018	0.027	0.034	0.075	0.501

	Wastewater Parameters	Raw Waste Level(2)	Effluent Quality					
	Flow, gal/ton	3200	125	0	70	70	70	70
	pH	6-10	6-9	-	6-9	6-9	6-9	6-9
	Concentrations, mg/l							
	Ammonia (as N)	10	103	-	50	50	1.0	1.0
	Cyanide, Total	10	15	-	2.5	2.5	1.0	1.0
	Phenols (4AAP)	2.5	4	-	3	3	0.1	0.05
	Fluoride	10	20	-	20	20	10	10
	Chlorine (Residual)	-	-	-	-	-	0.5	0.5
	Suspended Solids	1900	50	-	15	15	15	15
9	Hexachlorobenzene	0.01	0.01	-	0.01	0.01	0.01	0.01
31	2,4-Dichlorophenol	0.01	0.05	-	0.05	0.05	0.05	0.05
34	2,4-Dimethylphenol	0.05	0.25	-	0.25	0.25	0.05	0.05
39	Fluoranthene*	0.08	0.08	-	0.08	0.08	0.08	0.01
65	Phenol*	0.65	3.20	-	3.20	3.20	0.05	0.05
73	Benzo(a)pyrene	0.01	0.01	-	0.01	0.01	0.01	0.01
76	Chrysene	0.01	0.01	-	0.01	0.01	0.01	0.01
84	Pyrene	0.05	0.05	-	0.05	0.05	0.05	0.01
114	Antimony*	0.04	0.04	-	0.04	0.04	0.04	0.04
115	Arsenic*	0.05	0.05	-	0.05	0.05	0.05	0.05
118	Cadmium*	0.05	0.05	-	0.05	0.05	0.05	0.05
119	Chromium*	0.50	0.30	-	0.25	0.10	0.15	0.15
120	Copper*	0.20	0.10	-	0.10	0.10	0.10	0.10
122	Lead*	5.0	0.50	-	0.30	0.15	0.25	0.25
124	Nickel*	0.25	0.15	-	0.15	0.10	0.10	0.10
125	Selenium*	0.06	0.06	-	0.06	0.06	0.06	0.06
126	Silver*	0.01	0.01	-	0.01	0.01	0.01	0.01
128	Zinc*	20	5.0	-	4.5	0.25	0.30	0.30

---

(1) BAT costs are incremental over BAT feed costs.
(2) Levels represent a once-through wastewater system.
*: Toxic pollutant found in all raw waste samples analyzed.

SUMMARY OF EFFLUENT LOADINGS (TONS/YEAR) AND TREATMENT COSTS
IRONMAKING SUBCATEGORY

	Raw Waste Load	BAT Feed	BAT-1	BAT-2	BAT-3	BAT-4	BAT-5
Flow (MGD)	1,037	40.5	0	22.7	22.7	22.7	22.7
TSS	2,998,300	3082	0	517.8	517.8	517.8	517.8
Toxic Metals	41,280	385.9	0	190.2	31.41	38.32	38.32
Toxic Organics(1)	363	14.18	0	7.94	7.94	7.94	4.14
Ammonia (as N)	15,780	6349	0	1726	1726	34.52	34.52
Fluoride	15,780	1233	0	690.4	690.4	345.2	345.2
Cyanide, Total	15,780	924.6	0	86.30	86.30	34.52	34.52
Phenols	3,945	246.6	0	103.6	103.6	3.45	1.73

OPTION COSTS
(MILLIONS OF DOLLARS)

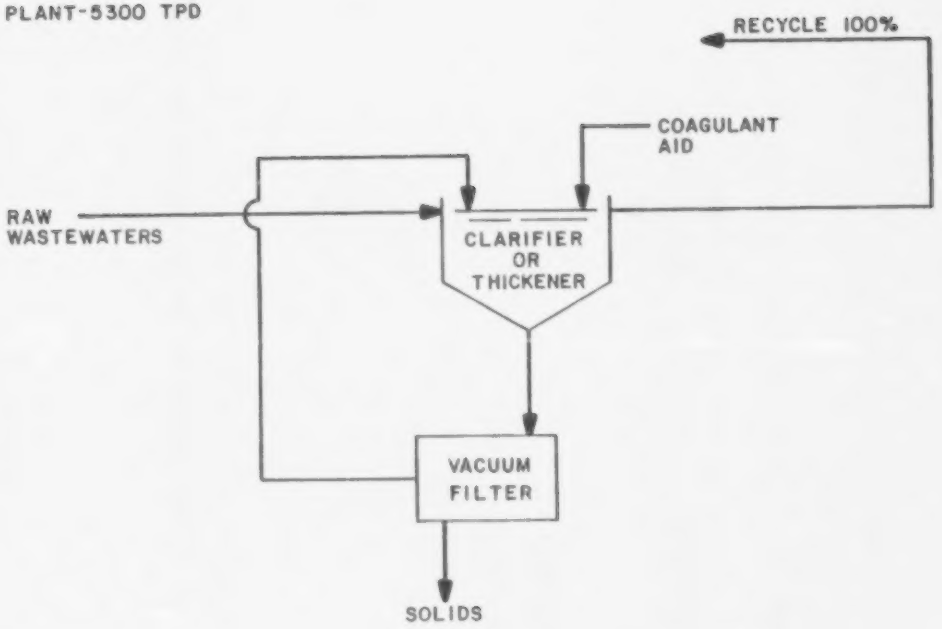
Model Plant (6000 Tons/Day)	BAT Feed	BAT-1	BAT-2	BAT-3	BAT-4	BAT-5
Investment	9.54	0.21	0.33	0.39	0.82	3.00
Annual	1.76	0.040	0.060	0.075	0.16	1.10
Subcategory (54 Plants)						
Investment	515.27	11.50	17.60	21.28	44.28	162.05
Annual	95.28	2.18	3.22	4.06	8.91	59.21

---

(1) Does not include phenols or any of the individual phenolic compounds.

BASIC OXYGEN FURNACE (SEMI-WET)

BPT
MODEL PLANT-5300 TPD


RECYCLE 100%
COAGULANT AID
RAW WASTEWATERS
CLARIFIER OR THICKENER
VACUUM FILTER
SOLIDS

SUBCATEGORY SUMMARY DATA
BASIS 7/1/78 DOLLARS

Subcategory: Basic Oxygen Furnace
: Semi-Wet
: Carbon and Specialty

Model Size-TPD : 5300
Oper. Days/Year: 365
Turns/Day : 3

Raw Waste Flows (MGD)	
Model Plant:	1.91
10 Semi-Wet Plants:	19.08

Model Costs	BPT
Investment Cost $ $\times 10^{-3}$	1462
Annual Cost $ $\times 10^{-3}$	297.5
$/Ton of Product	0.154

Wastewater Parameters	Raw Waste Level	BPT Level
Flow, gal/ton	360	0
pH (Units)	10-12	-
Concentrations. mg/l		
Suspended Solids	375	-
Fluoride	10	-
120 Copper*	0.04	-
122 Lead*	1.50	-
123 Mercury	0.003	-
128 Zinc*	1.00	-

---

* Toxic pollutant found in all raw waste samples analyzed.

SUMMARY OF EFFLUENT LOADINGS (TONS/YEAR) AND TREATMENT COSTS
BASIC OXYGEN FURNACE (SEMI-WET) SUBCATEGORY

	Raw Waste Load	BPT
Flow (MGD)	19.08	0
Suspended Solids	10,890	-
Fluoride	290.4	-
Toxic Metals	73.85	-
Toxic Organics	(1)	-

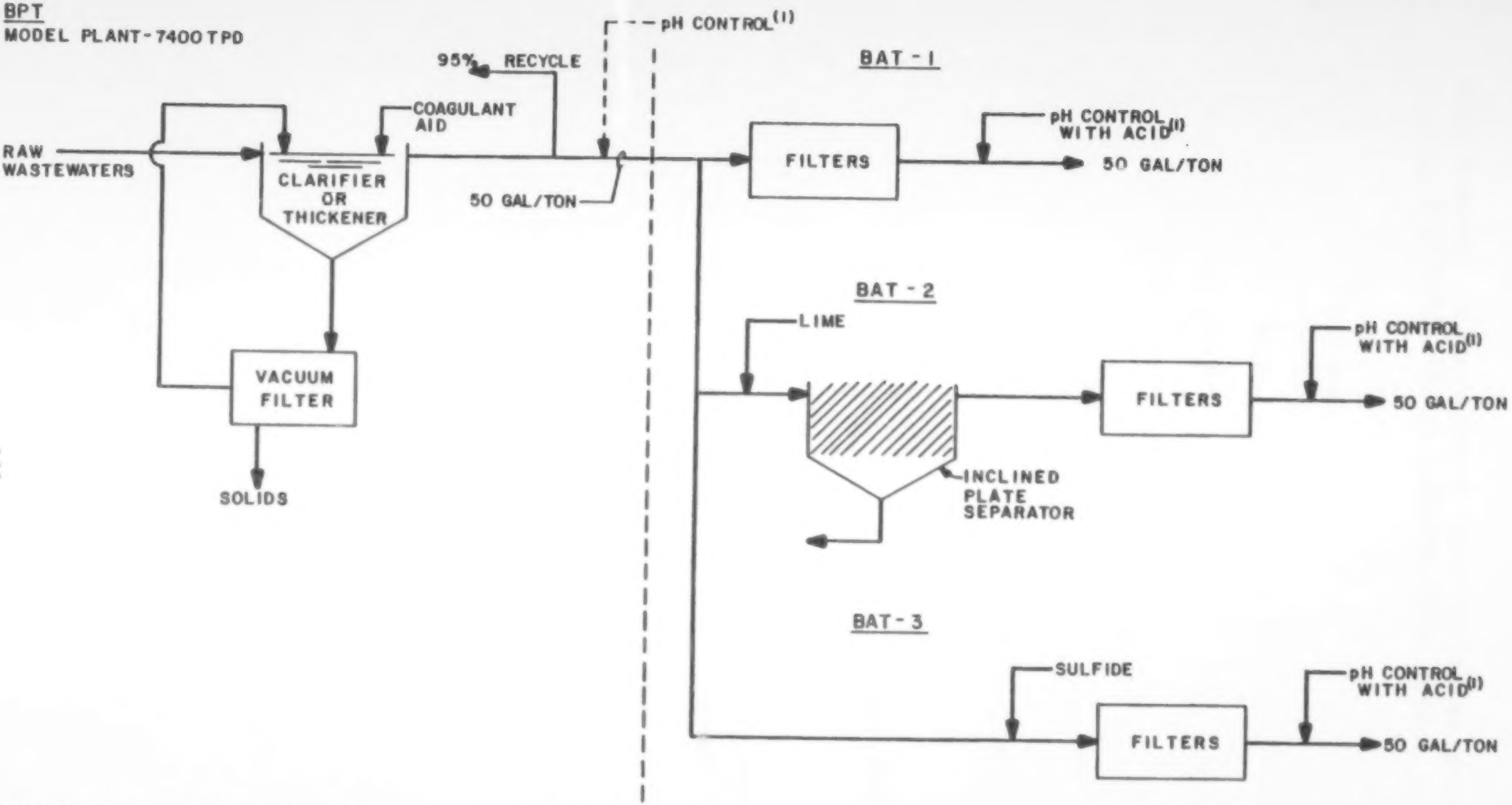
OPTION COSTS
(MILLIONS OF DOLLARS)

Model Plant (5300 tons/day)	BPT
Investment	1.46
Annual	0.30
Subcategory (10 plants)	
Investment	14.62
Annual	2.98

---

(1) No toxic organic pollutants were found at significant levels (e.g., >0.010 mg/l).

BASIC OYXGEN FURNACE (WET) - SUPPRESSED COMBUSTION


BPT
MODEL PLANT-7400 TPD
RAW WASTEWATERS
COAGULANT AID
CLARIFIER OR THICKENER
95% RECYCLE
pH CONTROL(1)
50 GAL/TON
VACUUM FILTER
SOLIDS
BAT - 1
FILTERS
pH CONTROL WITH ACID(1)
50 GAL/TON
BAT - 2
LIME
INCLINED PLATE SEPARATOR
FILTERS
pH CONTROL WITH ACID(1)
50 GAL/TON
BAT - 3
SULFIDE
FILTERS
pH CONTROL WITH ACID(1)
50 GAL/TON

---

(1) pH CONTROL WITH ACID IS A BPT STEP WHICH IS TRANSFERRED FOR INCORPORATION WITH BAT TREATMENT. THE COST OF THIS STEP IS NOT INCLUDED WITH THE BAT COSTS.

SUBCATEGORY SUMMARY DATA: BASIS 7/1/78 DOLLARS

Subcategory:	Basic Oxygen Furnace (Wet)	Model Size-TPD :	7400
:	Suppressed Combustion	Oper. Days/Year:	365
:	Carbon & Specialty	Turns/Day :	3

Raw Waste Flows	(MGD)
Model Plant:	7.4
6 Suppressed Combustion Plants:	44.4

Model Costs	BAT Feed	BAT Alternatives 1	2	3
Investment Cost $ x 10^{-3}	3170	108	423	171
Annual Cost $ x 10^{-3}	431.1	20.9	81.3	35.2
$/Ton of Product (1)	0.160	0.008	0.030	0.013

Wastewater Parameters	Raw Waste Loads	Effluent Quality			
Flow, gal/ton	1000	50	50	50	50
pH (Units)	8-11	6-9	6-9	6-9	6-9
Concentrations, mg/l					
Suspended Solids	1500	50	15	15	15
Fluoride	15	15	15	10	15
118 Cadmium*	0.10	0.10	0.10	0.10	0.10
119 Chromium*	0.50	0.10	0.10	0.10	0.10
120 Copper*	0.25	0.15	0.15	0.10	0.10
122 Lead*	15.00	3.50	2.00	0.30	0.15
124 Nickel*	0.50	0.25	0.25	0.10	0.10
126 Silver*	0.025	0.025	0.025	0.025	0.025
128 Zinc*	5.00	1.00	0.90	0.30	0.25

---

(1) BAT costs are incremental over BAT feed costs.

* Toxic pollutant found in all raw waste samples analyzed.

SUMMARY OF EFFLUENT LOADINGS (TONS/YEAR) AND TREATMENT COSTS
BASIC OXYGEN FURNACE (WET) SUBCATEGORY: SUPPRESSED COMBUSTION

	Raw Waste Load	BAT Feed	BAT No. 1	BAT No. 2	BAT No. 3
Flow (MGD)	44.4	2.22	2.22	2.22	2.22
TSS	101,370	168.9	50.68	50.68	50.68
Toxic Metals	1,445	17.32	11.91	3.46	2.79
Toxic Organics	(1)	(1)	(1)	(1)	(1)
Fluoride	1,014	50.68	50.68	33.79	50.68

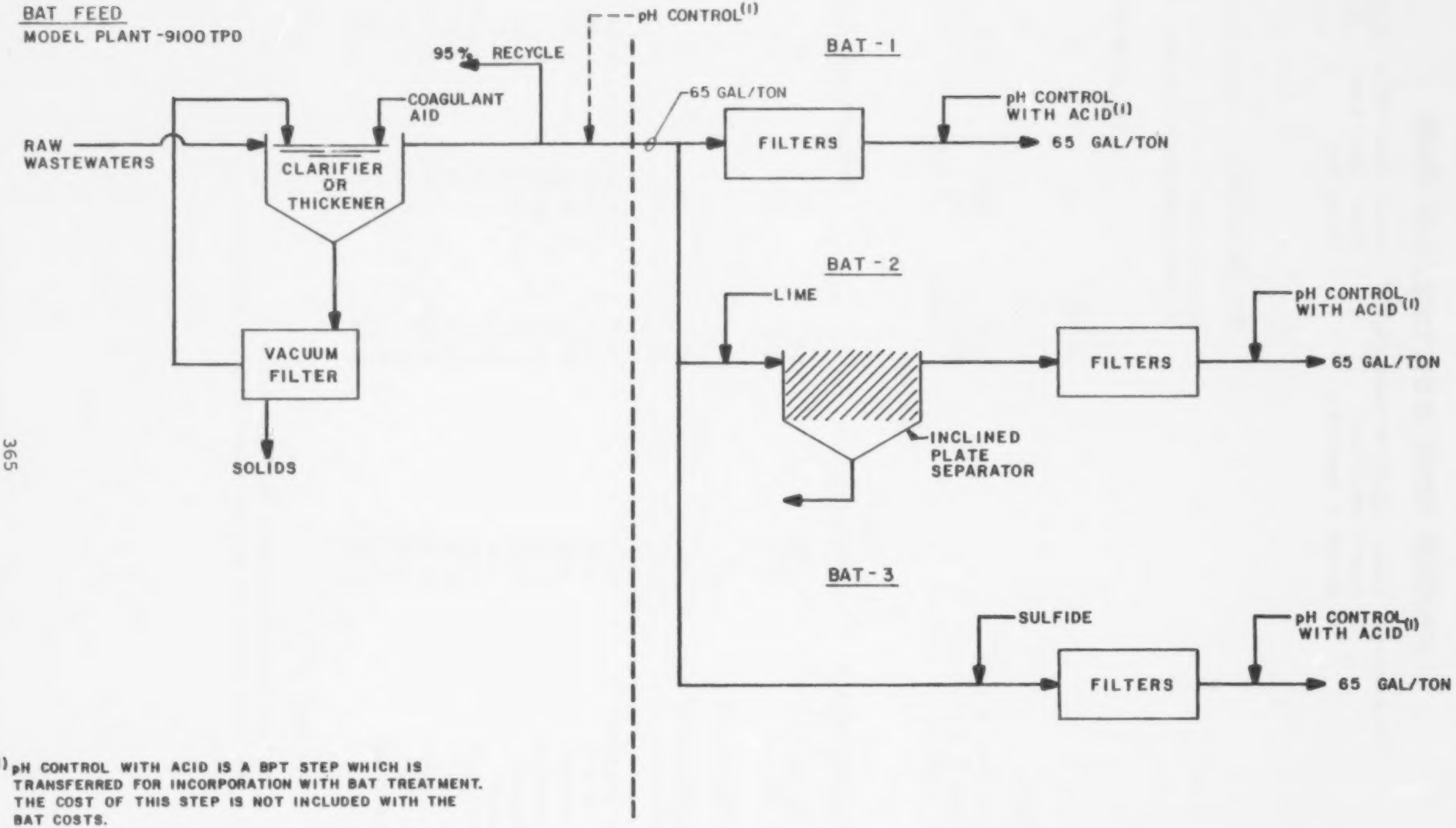
OPTION COSTS
(MILLIONS OF DOLLARS)

	BAT Feed	BAT No. 1	BAT No. 2	BAT No. 3
Model Plant (7400 Tons/Day)				
Investment	3.17	0.11	0.42	0.17
Annual	0.43	0.021	0.081	0.035
Subcategory (6 Plants)				
Investment	19.02	0.65	2.54	1.03
Annual	2.59	0.13	0.49	0.21

---

(1) No toxic organic pollutants were found at significant levels (i.e., >0.010 mg/1).

BASIC OXYGEN FURNACE (WET)-OPEN COMBUSTION


BAT FEED
MODEL PLANT-9100 TPD
RAW WASTEWATERS
CLARIFIER OR THICKENER
COAGULANT AID
95% RECYCLE
pH CONTROL(1)
VACUUM FILTER
SOLIDS
65 GAL/TON
BAT-1
FILTERS
pH CONTROL WITH ACID(1)
65 GAL/TON
BAT-2
LIME
INCLINED PLATE SEPARATOR
FILTERS
pH CONTROL WITH ACID(1)
65 GAL/TON
BAT-3
SULFIDE
FILTERS
pH CONTROL WITH ACID(1)
65 GAL/TON

(1) pH CONTROL WITH ACID IS A BPT STEP WHICH IS TRANSFERRED FOR INCORPORATION WITH BAT TREATMENT. THE COST OF THIS STEP IS NOT INCLUDED WITH THE BAT COSTS.

SUBCATEGORY SUMMARY DATA: BASIS 7/1/78 DOLLARS

Subcategory:	Basic Oxygen Furnace (Wet)	Model Size-TPD :	9100
:	Open Combustion	Oper. Days/Year:	365
:	Carbon & Specialty	Turns/Day :	3

Raw Waste Flows	(MGD)
Model Plant:	10.01
14 Open Combustion Plants:	140.1

			BAT Alternatives		
		BAT Feed	1	2	3
Model Costs					
Investment Cost \$ x 10^{-3}		5217	252	578	336
Annual Cost \$ x 10^{-3}		1360.5	48.9	113.8	68.7
\$/Ton of Product(1)		0.410	0.015	0.034	0.021
Wastewater Parameters	Raw Waste Level	Effluent Quality			
Flow, gal/ton	1100	65	65	65	65
pH (Units)	8-11	6-9	6-9	6-9	6-9
Concentrations, mg/l					
Suspended Solids	4200	50	15	15	15
Fluoride	15	15	15	10	15
23 Chloroform*	0.05	0.05	0.05	0.05	0.05
115 Arsenic*	0.05	0.05	0.05	0.05	0.05
118 Cadmium*	0.50	0.30	0.30	0.10	0.10
119 Chromium*	5.00	1.00	0.80	0.25	0.10
120 Copper*	0.50	0.25	0.15	0.10	0.10
122 Lead*	1.00	0.50	0.30	0.25	0.15
123 Mercury*	0.01	0.01	0.005	0.005	0.005
124 Nickel*	0.50	0.30	0.30	0.10	0.10
125 Selenium*	0.025	0.025	0.025	0.025	0.025
126 Silver*	0.20	0.15	0.15	0.15	0.15
127 Thallium*	0.10	0.10	0.10	0.10	0.10
128 Zinc*	5.00	1.00	0.90	0.30	0.25

---

(1) BAT costs are incremental over BAT feed costs.

* Toxic pollutant found in all raw waste samples analyzed.

SUMMARY OF EFFLUENT LOADINGS (TONS/YEAR) AND TREATMENT COSTS
BASIC OXYGEN FURNACE (WET) SUBCATEGORY: OPEN COMBUSTION

	Raw Waste Load	BAT Feed	BAT No. 1	BAT No. 2	BAT No. 3
Flow (MGD)	140.1	8.3	8.3	8.3	8.3
TSS	895,860	630.2	189.1	189.1	189.1
Toxic Metals	2748	46.45	38.82	18.02	13.61
Toxic Organics	10.67	0.63	0.63	0.63	0.63
Fluoride	3200	189.1	189.1	126.0	189.1

NOTE: Incidental organics removal expected at BAT.

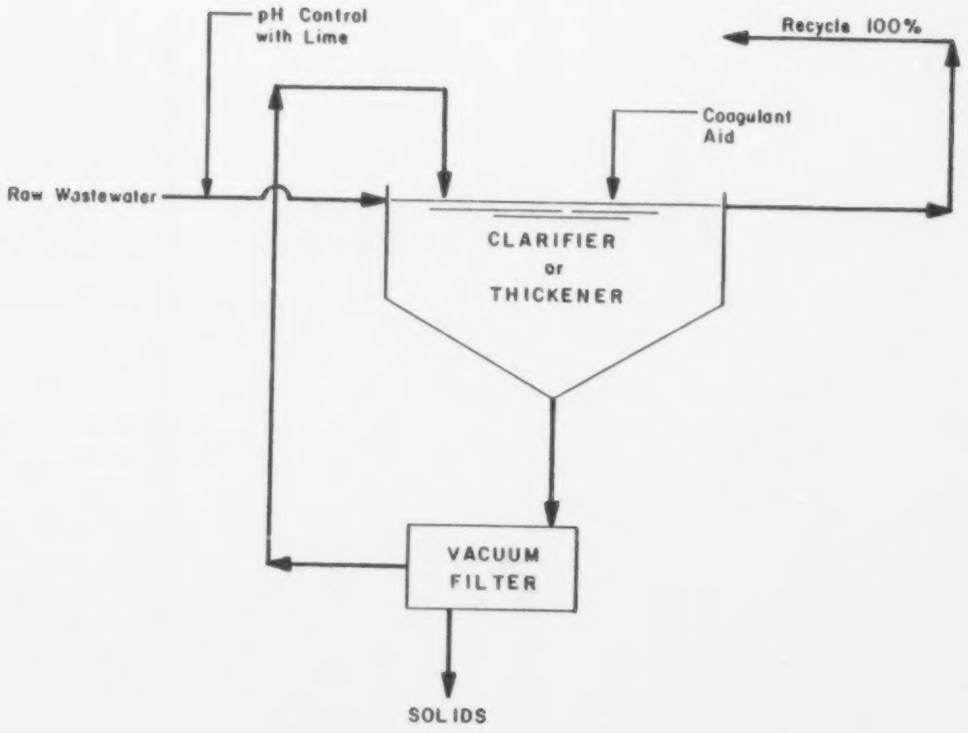
OPTION COSTS
(MILLIONS OF DOLLARS)

	BAT Feed	BAT No. 1	BAT No. 2	BAT No. 3
Model Plant (9100 Tons/Day)				
Investment	5.22	0.25	0.58	0.34
Annual	1.36	0.049	0.11	0.069
Subcategory (14 Plants)				
Investment	73.04	3.53	8.09	4.70
Annual	19.05	0.68	1.59	0.96

OPEN HEARTH FURNACE (SEMI-WET)

BPT

Model Plant - 6 600 TPD


pH Control
with Lime
Recycle 100%
Coagulant
Aid
Raw Wastewater
CLARIFIER
or
THICKENER
VACUUM
FILTER
SOLIDS

SUBCATEGORY SUMMARY DATA
BASIS 7/1/78 DOLLARS

Subcategory:	Open Hearth Furnace	Model Size-TPD :	6600
:	Semi-Wet	Oper. Days/Year:	365
:	Carbon and Specialty	Turns/Day :	3

Raw Waste Flows (MGD)

Model Plant:	7.26
1 Semi-Wet Plant:	7.26

Model Costs	BPT
Investment Cost $ x 10^{-3}	3499
Annual Cost $ x 10^{-3}	848.6
$/Ton of Product	0.352

	Wastewater Parameters	Raw Waste Level	BPT Level
	Flow, gal/ton	1100	0
	pH (Units)	2-3	-
	Concentrations, mg/l		
	Suspended Solids	500	-
	Fluoride	260	-
119	Chromium*	0.08	-
120	Copper*	0.08	-
121	Cyanides, Total*	0.04	-
124	Nickel*	0.05	-
128	Zinc*	0.6	-

---

* Toxic pollutant found in all raw waste samples analyzed.

SUMMARY OF EFFLUENT LOADINGS (TONS/YEAR) AND TREATMENT COSTS OPEN HEARTH FURNACE (SEMI-WET) SUBCATEGORY

	Raw Waste Load	BPT
Flow (MGD)	7.26	0
TSS	5525	-
Fluoride	2873	-
Toxic Metals	8.95	-
Cyanide (T)	0.44	-
Toxic Organics	(1)	

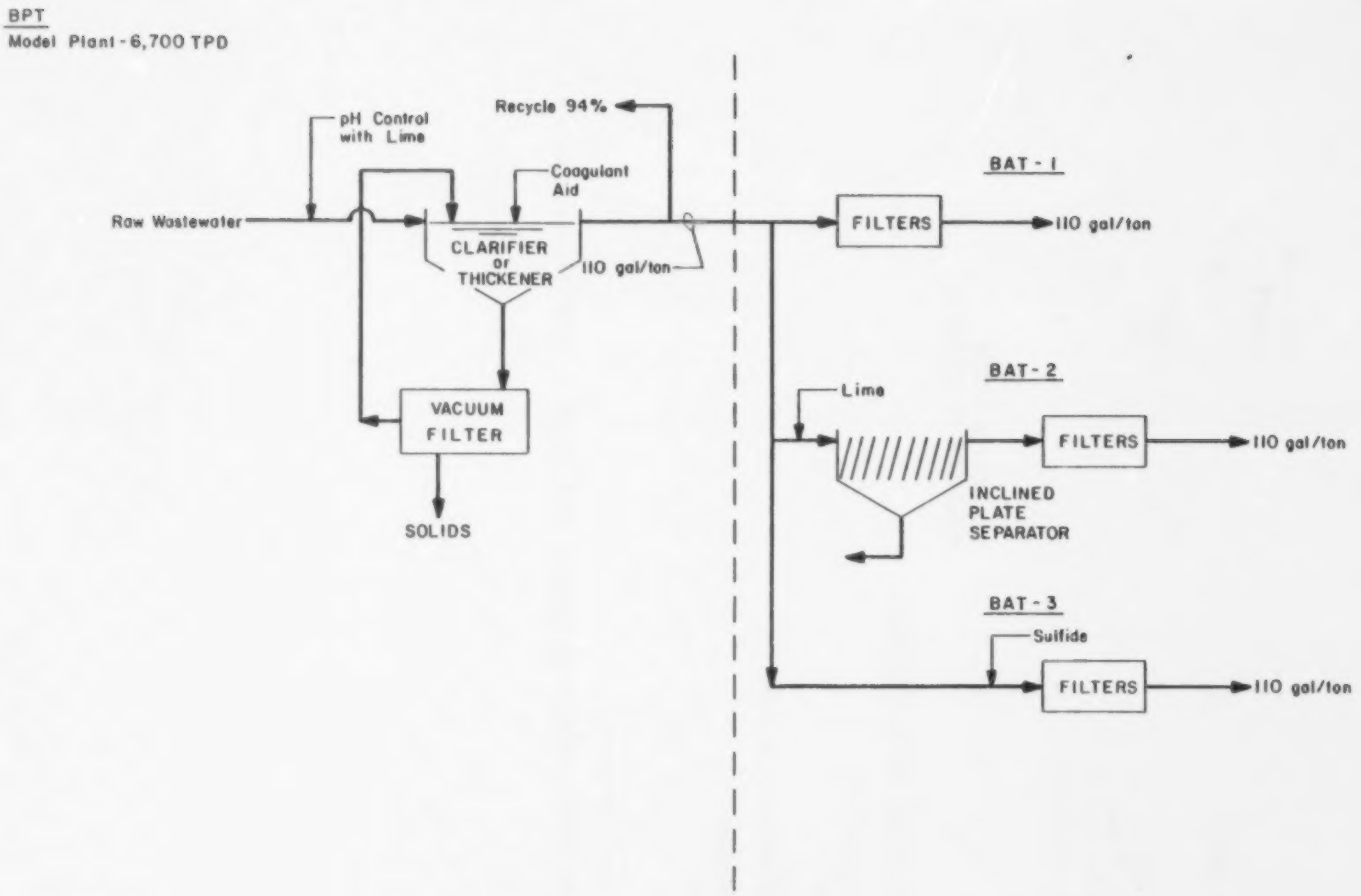
OPTION COSTS (MILLIONS OF DOLLARS)

Model Plant (6600 tons/day)	BPT
Investment	3.50
Annual	0.85
Subcategory (1 plant)	
Investment	3.50
Annual	0.85

---

(1) No toxic organic pollutants were found at significant levels (i.e., >0.010 mg/1).

OPEN HEARTH FURNACE (WET)


BPT
Model Plant - 6,700 TPD
Raw Wastewater
pH Control with Lime
Coagulant Aid
Recycle 94%
CLARIFIER or THICKENER
110 gal/ton
VACUUM FILTER
SOLIDS
BAT - 1
FILTERS
110 gal/ton
BAT - 2
Lime
INCLINED PLATE SEPARATOR
FILTERS
110 gal/ton
BAT - 3
Sulfide
FILTERS
110 gal/ton

SUBCATEGORY SUMMARY DATA: BASIS 7/1/78 DOLLARS

Subcategory:	Open Hearth Furnace	Model Size-TPD :	6700
:	Wet	Oper. Days/Year:	365
:	Carbon & Specialty	Turns/Day :	3

Raw Waste Flows (MGD)

Model Plant: 12.7
3 Wet Plants: 38.2

	Raw Waste Loads	BAT Feed	BAT Alternatives 1	BAT Alternatives 2	BAT Alternatives 3
Model Costs					
Investment Cost \$ x 10^{-3}		5515	287	787	383
Annual Cost \$ x 10^{-3}		1270.6	56.1	380.8	79.3
\$/Ton of Product (1)		0.520	0.023	0.156	0.032
Wastewater Parameters		Effluent Quality			
Flow, gal/ton	1900	110	110	110	110
pH (Units)	3-7	6-9	6-9	6-9	6-9
Concentrations, mg/l					
Suspended Solids	1100	50	15	15	15
Fluoride	110	100	100	20	100
120 Copper	2.0	0.25	0.15	0.10	0.10
122 Lead	0.6	0.50	0.25	0.15	0.15
128 Zinc*	200	5.00	4.50	0.30	0.25

---

(1) BAT costs are incremental over BAT feed costs.
*: Toxic pollutant found in all raw waste samples analyed.

SUMMARY OF EFFLUENT LOADINGS (TONS/YEAR) AND TREATMENT COSTS
OPEN HEARTH (WET) SUBCATEGORY

	Raw Waste Load	BAT Feed	BAT No. 1	BAT No. 2	BAT No. 3
Flow (MGD)	38.19	2.21	2.21	2.21	2.21
TSS	63,940	168.3	50.48	50.48	50.48
Toxic Metals	11,780	19.35	16.49	1.85	1.68
Toxic Organics	(1)	(1)	(1)	(1)	(1)
Fluoride	6,394	336.5	336.5	67.31	336.5

OPTION COSTS
(MILLIONS OF DOLLARS)

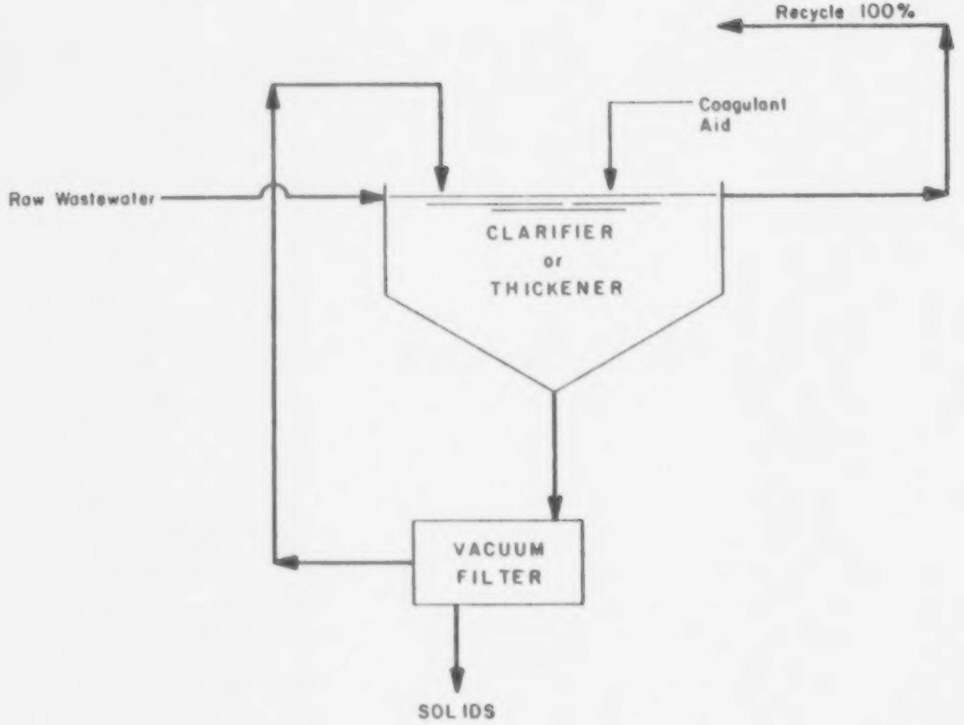
	BAT Feed	BAT No. 1	BAT No. 2	BAT No. 3
Model Plant (6700 Tons/Day)				
Investment	5.52	0.29	0.79	0.38
Annual	1.27	0.056	0.38	0.079
Subcategory (3 Plants)				
Investment	16.54	0.86	2.36	1.15
Annual	3.81	0.17	1.14	0.24

---

(1) No toxic organic pollutants were found at significant levels (e.g. >0.010 mg/1).

ELECTRIC FURNACE (SEMI-WET)

BPT
Model Plant - 3 100 TPD


Recycle 100%
Coagulant Aid
Raw Wastewater
CLARIFIER
or
THICKENER
VACUUM
FILTER
SOL IDS

SUBCATEGORY SUMMARY DATA
BASIS 7/1/78 DOLLARS

Subcategory:	Electric Arc Furnace	Model Size-TPD :	3100
:	Semi-Wet	Oper. Days/Year:	365
:	Carbon and Specialty	Turns/Day :	3

Raw Waste Flows (MGD)	
Model Plants:	0.46
3 Semi-Wet Plants:	1.40

Model Costs	BPT
Investment Cost \$ x 10^{-3}	970
Annual Cost \$ x 10^{-3}	211.1
\$/Ton of Product	0.187

Wastewater Parameters	Raw Waste Level	BPT Level
Flow, gal/ton	150	0
pH (Units)	6-9	-
Concentrations, mg/l		
Suspended Solids	2200	-
Fluoride	30	-
120 Copper*	2	-
122 Lead*	30	-
128 Zinc*	125	-

---

* Toxic pollutant found in all raw waste samples analyzed.

SUMMARY OF EFFLUENT LOADINGS (TONS/YEAR) AND TREATMENT COSTS ELECTRIC ARC FURNACE (SEMI-WET) SUBCATEGORY

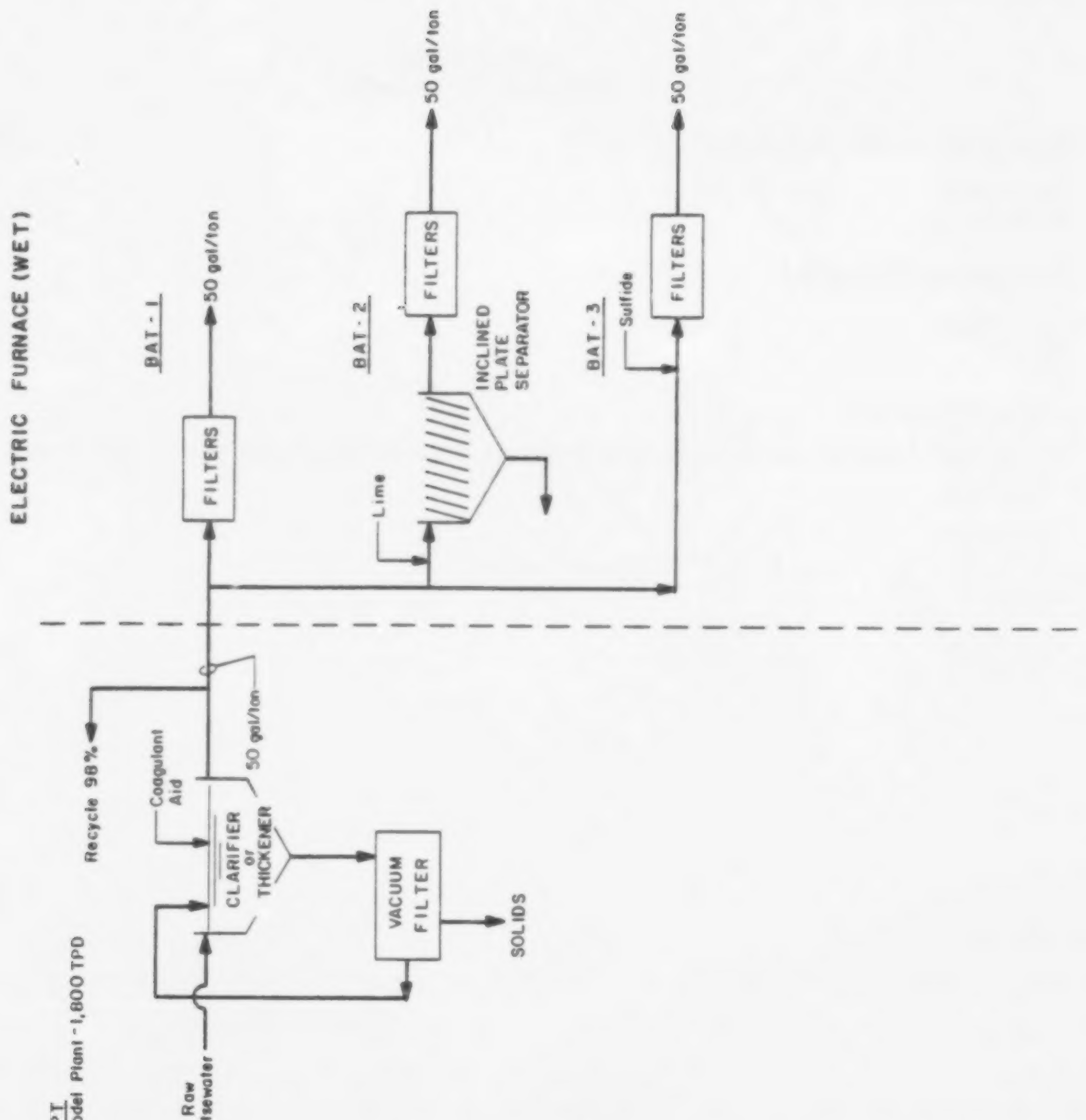
	Raw Waste Load	BPT
Flow (MGD)	1.40	0
TSS	4671	-
Fluoride	63.70	-
Toxic Metals	333.4	-
Toxic Organics	(1)	-

OPTION COSTS
(MILLIONS OF DOLLARS)

Model Plant (3100 tons/day)	BPT
Investment	0.97
Annual	0.21
Subcategory (3 plants)	
Investment	2.91
Annual	0.63

---

(1) No toxic organic pollutants were found at significant levels (i.e, >0.010 mg/1).


ELECTRIC FURNACE (WET)
BPT
Model Plant - 1,800 TPD
Raw Wastewater
CLARIFIER or THICKENER
Coagulant Aid
Recycle 98%
50 gal/ton
VACUUM FILTER
SOLIDS
BAT - 1
FILTERS
50 gal/ton
BAT - 2
Lime
INCLINED PLATE SEPARATOR
FILTERS
50 gal/ton
BAT - 3
Sulfide
FILTERS
50 gal/ton

SUBCATEGORY SUMMARY DATA: BASIS 7/1/78 DOLLARS

Subcategory:	Electric Arc Furnace	Model Size-TPD :	1800
:	Wet	Oper. Days/Year:	365
:	Carbon & Specialty	Turns/Day :	3

Raw Waste Flows:	(MGD)
Model Plant:	3.78
9 Electric Arc Furnace Plants:	34.0

Model Costs	BAT Feed	BAT Alternatives 1	2	3
Investment Cost $ x 10^{-3}	2689	102	239	126
Annual Cost $ x 10^{-3}	925.2	18.7	44.9	23.9
$/Ton of Product(1)	1.41	0.028	0.068	0.036

	Wastewater Parameters	Raw Waste Loads	Effluent Quality BAT Feed	1	2	3
	Flow, gal/ton	2100	50	50	50	50
	pH (Units)	6-9	6-9	6-9	6-9	6-9
	Concentrations, mg/l					
	Suspended Solids	3400	50	15	15	15
	Fluoride	50	50	50	20	50
4	Benzene*	0.015	0.015	0.015	0.015	0.015
39	Fluoranthene	0.020	0.020	0.020	0.020	0.020
58	4-Nitrophenol	0.015	0.015	0.015	0.015	0.015
64	Pentachlorophenol	0.015	0.015	0.015	0.015	0.015
84	Pyrene	0.020	0.020	0.020	0.020	0.020
114	Antimony*	0.70	0.10	0.10	0.10	0.10
115	Arsenic*	2.0	0.10	0.10	0.10	0.10
118	Cadmium*	4.0	2.0	1.9	0.10	0.10
119	Chromium*	5.0	0.50	0.40	0.15	0.10
120	Copper*	2.0	0.25	0.15	0.10	0.10
122	Lead*	30.0	2.5	1.50	0.30	0.15
124	Nickel*	0.05	0.05	0.05	0.05	0.05
126	Silver*	0.06	0.06	0.06	0.06	0.06
128	Zinc*	125	30	25	0.35	0.25

---

(1) BAT costs are incremental over BAT feed costs.

* Toxic pollutant found in all raw waste samples analyzed.

SUMMARY OF EFFLUENT LOADINGS (TONS/YEAR) AND TREATMENT COSTS
ELECTRIC ARC FURNACE (WET) SUBCATEGORY

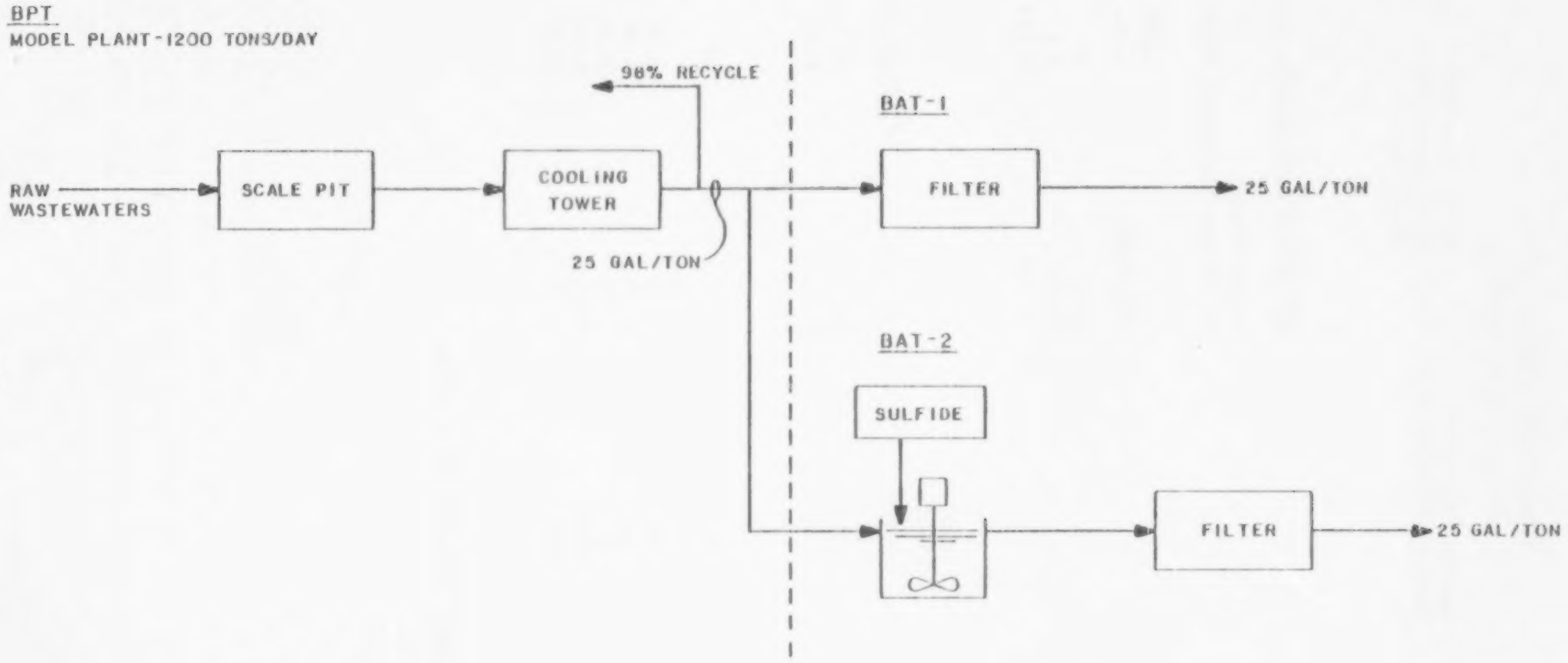
	Raw Waste Load	BAT Feed	BAT No. 1	BAT No. 2	BAT No. 3
Flow (MGD)	34.02	0.81	0.81	0.81	0.81
TSS	176,050	61.64	18.49	18.49	18.49
Toxic Metals	8,741	43.84	36.07	1.62	1.25
Toxic Organics	4.40	0.10	0.10	0.10	0.10
Fluoride	2,589	61.64	61.64	24.66	61.64

NOTE: Incidental organics removal expected at BAT.

OPTION COSTS
(MILLIONS OF DOLLARS)

	BAT Feed	BAT No. 1	BAT No. 2	BAT No. 3
Model Plant (1800 Tons/Day)				
Investment	2.69	0.10	0.24	0.13
Annual	0.93	0.019	0.045	0.024
Subcategory (9 Plants)				
Investment	24.20	0.92	2.15	1.13
Annual	8.33	0.17	0.40	0.22

VACUUM DEGASSING
TREATMENT MODELS SUMMARY


BPT
MODEL PLANT-1200 TONS/DAY
RAW WASTEWATERS
SCALE PIT
COOLING TOWER
98% RECYCLE
25 GAL/TON
BAT-1
FILTER
25 GAL/TON
BAT-2
SULFIDE
FILTER
25 GAL/TON

SUBCATEGORY SUMMARY DATA
BASIS 7/1/78 DOLLARS

Subcategory: Vacuum Degassing
: Carbon and Specialty

Model Size-TPD : 1200
Oper. Days/Year: 365
Turns/Day : 3

Raw Wastewater Flows:	MGD
Model Plant:	1.68
34 Vacuum Degassing Plants:	57.1

Model Costs	BAT Feed	BAT Alternatives 1	2
Investment Cost $ x 10^{-3}	1116	32	66
Annual Cost $ x 10^{-3}	225.1	5.9	12.7
$/Ton of Product (1)	0.51	0.013	0.029

Wastewater Parameters	Raw Waste Loads	Effluent Quality		
Flow, gal/ton	1400	25	25	25
pH (Units)	6-9	6-9	6-9	6-9
Concentrations, mg/l				
Suspended Solids	80	50	15	15
119 Chromium	1.0	0.35	0.10	0.10
120 Copper	0.20	0.10	0.10	0.10
122 Lead	5.0	0.35	0.10	0.10
124 Nickel	0.03	0.03	0.03	0.03
128 Zinc	5.0	0.35	0.10	0.10

---

(1) BAT costs are incremental over BAT feed costs.

SUMMARY OF EFFLUENT LOADINGS (TONS/YEAR) AND TREATMENT COSTS
VACUUM DEGASSING

	Raw Waste Load	BAT Feed	BAT No.1	BAT No.2
Flow (MGD)	57.1	1.02	1.02	1.02
TSS	6955	77.62	23.29	23.29
Metals	976	1.83	0.67	0.67
Organics	(1)	(1)	(1)	(1)

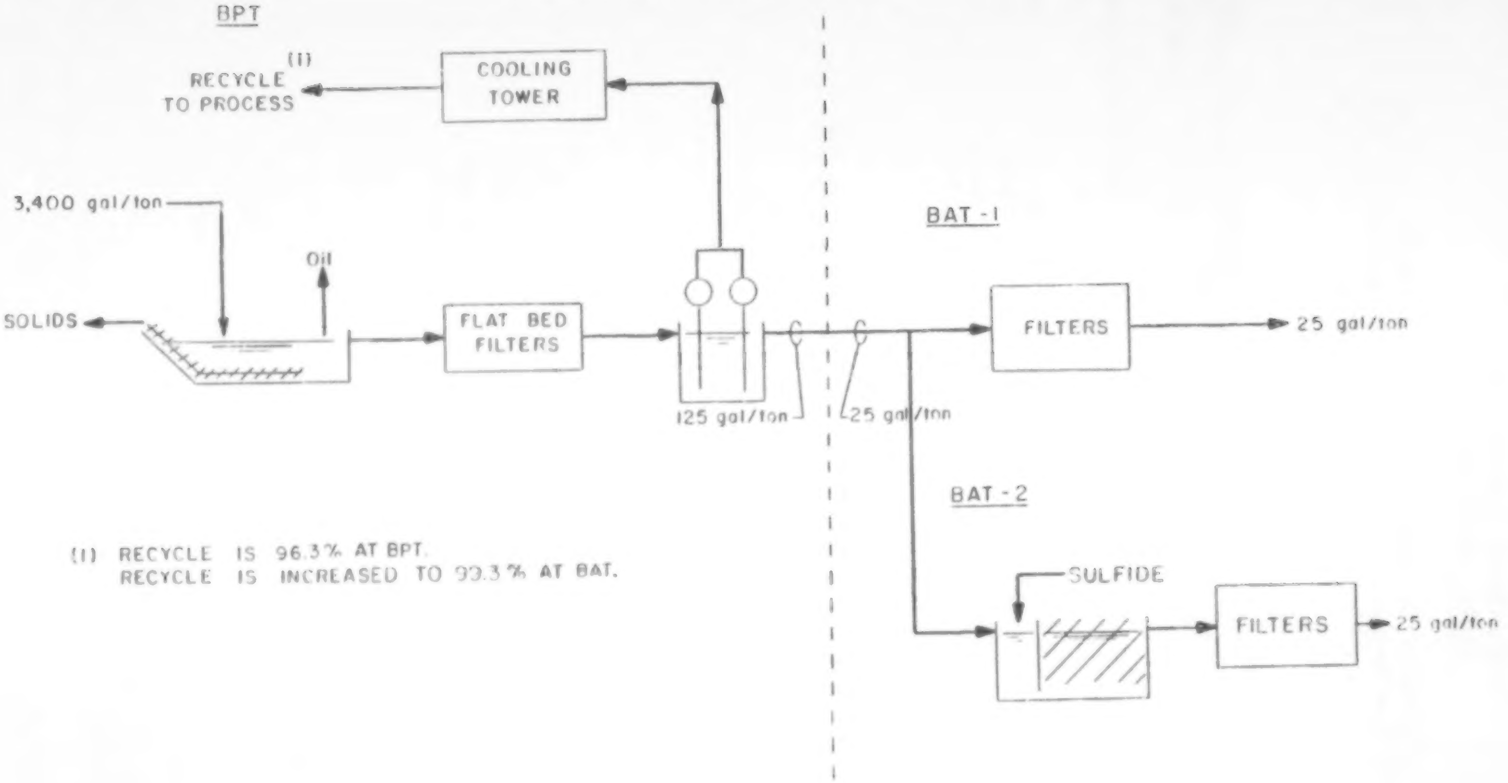
OPTION COSTS (MILLIONS OF DOLLARS)

	BAT Feed	BAT No.1	BAT No.2
Model Plant (1200 tons/day)			
Investment	1.12	0.032	0.066
Annual	0.23	0.0059	0.013
Subcategory (34 Plants)			
Investment	37.94	1.09	2.24
Annual	7.65	0.20	0.43

---

(1) No organic pollutants were found at significant levels (e.g. >10 ppb).

CONTINUOUS CASTING
TREATMENT MODEL SUMMARY


BPT
RECYCLE TO PROCESS (1)
COOLING TOWER
3,400 gal/ton
OIL
SOLIDS
FLAT BED FILTERS
125 gal/ton
25 gal/ton
BAT-1
FILTERS
25 gal/ton
BAT-2
SULFIDE
FILTERS
25 gal/ton

(1) RECYCLE IS 96.3% AT BPT.
RECYCLE IS INCREASED TO 99.3% AT BAT.

SUBCATEGORY SUMMARY TABLE
BASIS 7/1/78 DOLLARS

Subcategory: Continuous Casting
: Carbon/Specialty

Model Size-TPD : 1400
Oper. Days/Year: 365
Turns/Day : 3

Raw Waste Flows		(MGD)
Model Plant	:	4.76
50 Plants	:	238.0

Model Costs	BAT Feed	BAT Alternatives 1	BAT Alternatives 2
Investment Cost \$ x 10^{-3}	2304	87	109
Annual Cost \$ x 10^{-3}	478.1	15.6	20.0
\$/Ton of Product(1)	0.94	0.031	0.039

Wastewater Pollutants	Raw Waste Level	Effluent Quality		
Flow (gal/ton)	3400	25	25	25
pH, Units	6-9	6-9	6-9	6-9
Concentrations (mg/l)				
Suspended Solids	60	50	15	15
Oil & Grease	25	15	5	5
119 Chromium	0.65	0.65	0.10	0.10
120 Copper	0.11	0.11	0.10	0.10
122 Lead	0.090	0.090	0.090	0.090
125 Selenium	0.080	0.080	0.080	0.080
128 Zinc	0.70	0.70	0.10	0.10

---

(1) BAT costs are incremental over BAT Feed Costs.

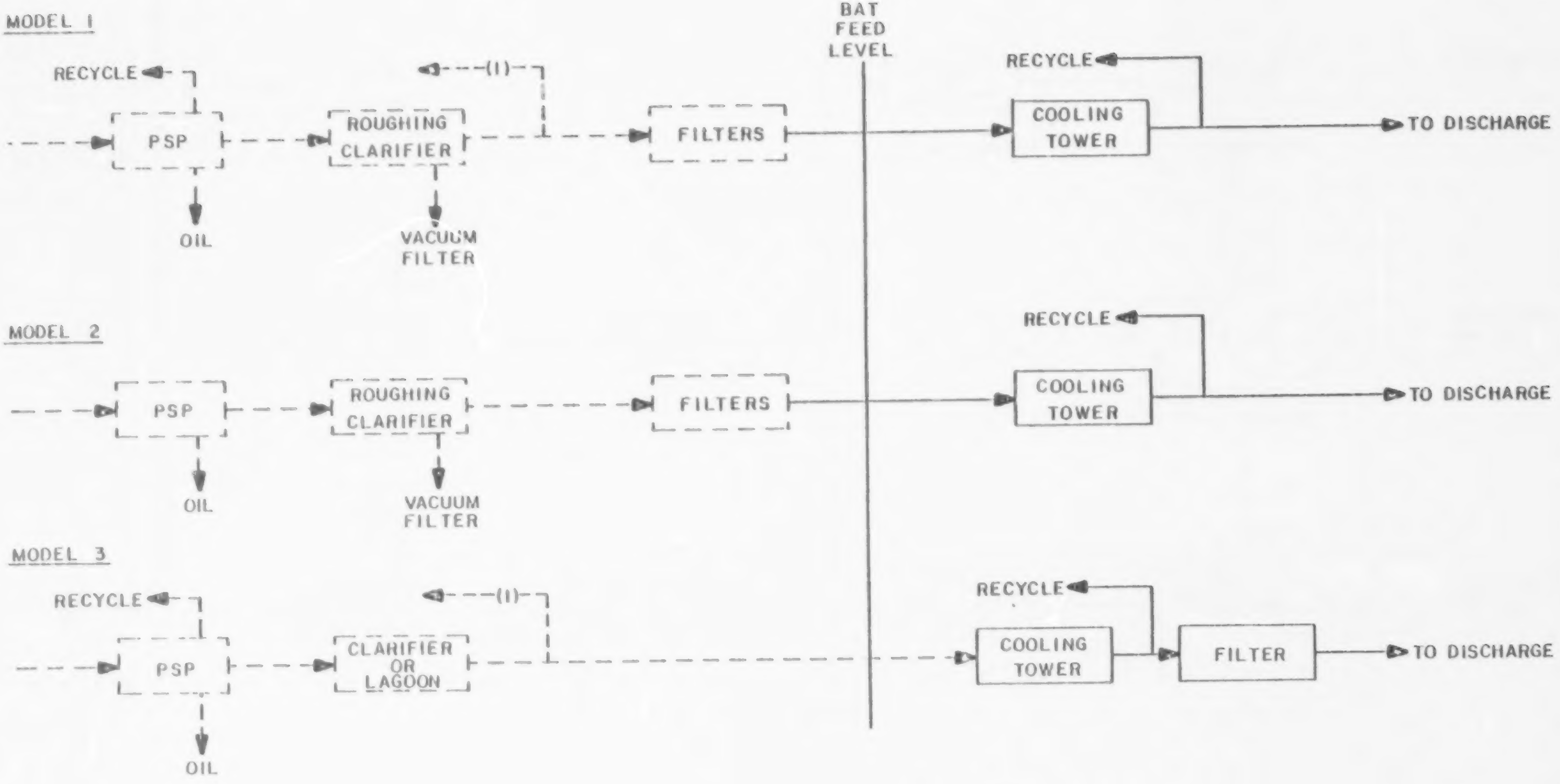
SUMMARY OF EFFLUENT LOADINGS (TONS/YEAR) AND TREATMENTS COSTS CONTINUOUS CASTING SUBCATEGORY

	Raw Waste Load	BAT Feed	BAT No.1	BAT No.2
Flow (MGD)	238	1.8	1.8	1.8
TSS	21,735	133.1	40.0	40.0
Oils	9,056	40.0	13.3	13.3
Toxic Metals	590.5	4.3	1.3	1.3

OPTION COSTS (MILLIONS OF DOLLARS)

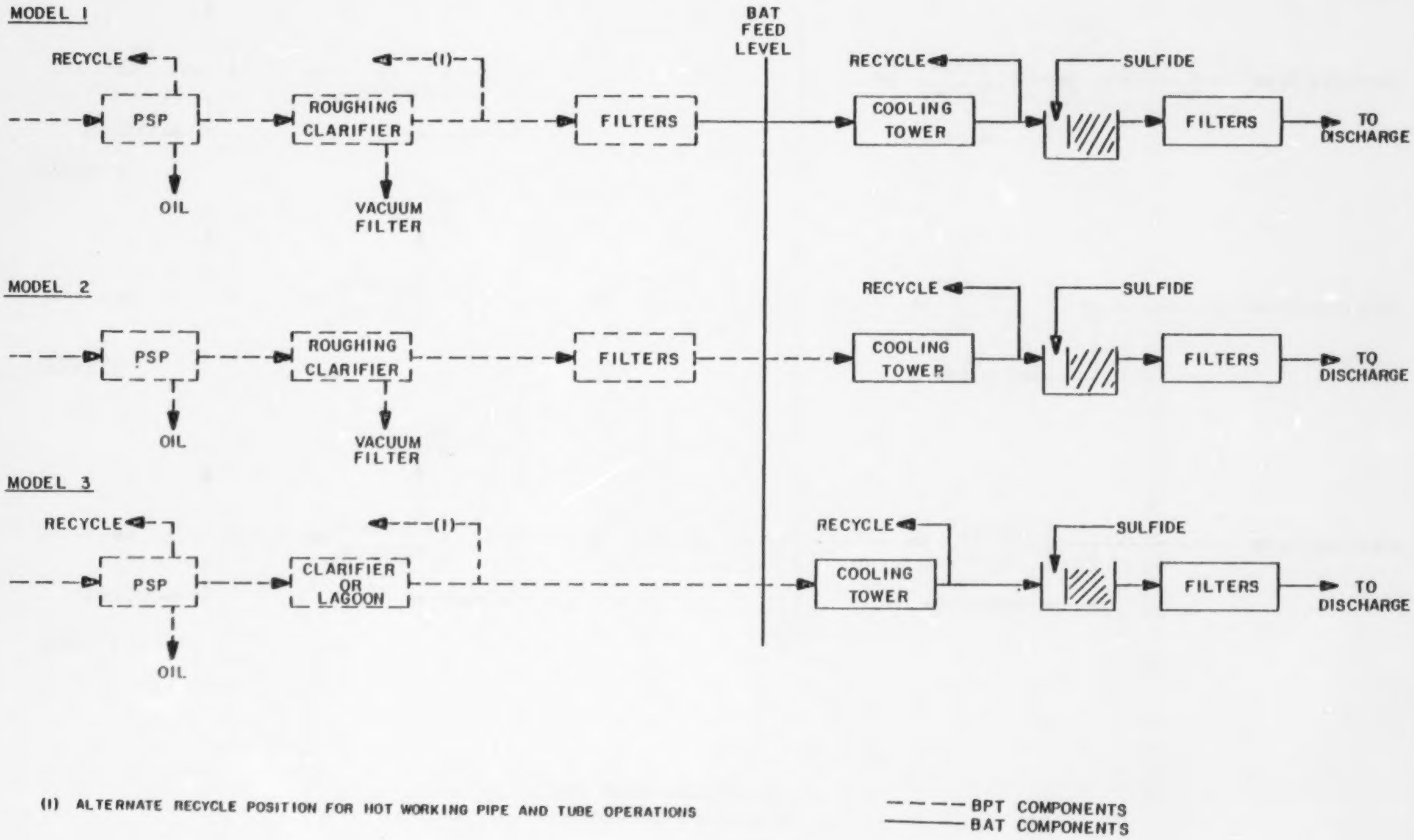
	BAT Feed	BAT No.1	BAT No.2
Model Plant (1400 tons/day)			
Investment	2.30	0.087	0.11
Annual	0.48	0.016	0.020
Subcategory (50 plants)			
Investment	115.20	4.35	5.45
Annual	23.90	0.78	1.00

HOT FORMING SUBCATEGORY
BAT MODEL - ALTERNATIVE I


MODEL 1
RECYCLE
PSP
OIL
ROUGHING CLARIFIER
VACUUM FILTER
(1)
FILTERS
BAT FEED LEVEL
COOLING TOWER
RECYCLE
TO DISCHARGE
MODEL 2
PSP
OIL
ROUGHING CLARIFIER
VACUUM FILTER
FILTERS
COOLING TOWER
RECYCLE
TO DISCHARGE
MODEL 3
RECYCLE
PSP
OIL
CLARIFIER OR LAGOON
(1)
COOLING TOWER
RECYCLE
FILTER
TO DISCHARGE
- - - - BPT COMPONENTS
——— BAT COMPONENTS

(1) ALTERNATE RECYCLE POSITION FOR HOT WORKING PIPE AND TUBE OPERATIONS

HOT FORMING SUBCATEGORY
BAT MODEL - ALTERNATIVE 2


MODEL 1
RECYCLE
PSP
OIL
ROUGHING CLARIFIER
VACUUM FILTER
(1)
FILTERS
BAT FEED LEVEL
RECYCLE
COOLING TOWER
SULFIDE
FILTERS
TO DISCHARGE
MODEL 2
PSP
OIL
ROUGHING CLARIFIER
VACUUM FILTER
FILTERS
RECYCLE
COOLING TOWER
SULFIDE
FILTERS
TO DISCHARGE
MODEL 3
RECYCLE
PSP
OIL
CLARIFIER OR LAGOON
(1)
RECYCLE
COOLING TOWER
SULFIDE
FILTERS
TO DISCHARGE
BPT COMPONENTS
BAT COMPONENTS

(1) ALTERNATE RECYCLE POSITION FOR HOT WORKING PIPE AND TUBE OPERATIONS

SUBCATEGORY SUMMARY DATA
BASIS 7/1/78 DOLLARS

			Model Type		
			(1)	(2)	(3)
Subcategory:	Hot Forming	Model Size (TPD)	-	4400	6700
:	Primary	Operation (Days/Yr)	260	260	260
:	Carbon Without Scarfers	Turns/Day	3	3	3

Model Type	Model Applied Flow (MGD)	No. of Plants
1	-	0
2	10.1	1
3	15.4	27
		28

Total Flow (28 Plants) = 425.9 MGD

Model Costs	Model 3 BAT Feed	BAT 1			BAT 2		
		1	2	3	1	2	3
Investment Cost \$ x 10^{-3}	1971	-	2666	2531	-	2941	2572
Annual Cost \$ x 10^{-3}	-1329	-	544.4	510.6	-	596.6	520.8
\$/Ton of Production	-0.76	-	0.48	0.29	-	0.52	0.30

Wastewater Parameters		Raw Waste Levels	BAT Feed	BAT 1	BAT 2
	Flow (GPT)	2300	2300 (1150)(1)	90	90
	pH, Units	6-9	6-9 (6-9)	6-9	6-9
	Suspended Solids	2190	15 (30)	15	15
	Oil & Grease	84	5 (10)	5	5
119	Chromium	2.9	0.1 (0.1)	0.1	0.1
120	Copper	2.9	0.1 (0.1)	0.1	0.1
122	Lead	1.5	0.1 (0.1)	0.1	0.1
124	Nickel	1.4	0.1 (0.2)	0.1	0.1
128	Zinc	3.2	0.1 (0.1)	0.1	0.1

---

(1) Model 3 BAT feed values appear in parenthesis.

NOTE: All units mg/l unless otherwise noted.

SUBCATEGORY SUMMARY DATA
BASIS 7/1/78 DOLLARS

			Model Type		
			(1)	(2)	(3)
Subcategory:	Hot Forming	Model Size (TPD)	2200	4400	6700
:	Primary	Operation (Days/Yr)	260	260	260
:	Carbon With Scarfers	Turns/Day	3	3	3

Model Type	Model Applied Flow (MGD)	No. of Plants
1	7.5	1
2	15.0	2
3	22.8	28
		31

Total Flow (31 Plants) = 675.9 MGD

Model Costs	Model 3 BAT Feed	BAT 1			BAT 2		
		1	2	3	1	2	3
Investment Cost \$ x 10^{-3}	2852	1380	3386	3365	1655	3720	3412
Annual Cost \$ x 10^{-3}	-2515	277.6	713.2	682.7	329.8	777.6	695.4
\$/Ton of Production	-1.44	0.49	0.62	0.39	0.58	0.68	0.40

	Wastewater Parameters	Raw Waste Levels	BAT Feed	BAT 1	BAT 2
	Flow (GPT)	3400	1700(1) (1700)(2)	140	140
	pH, Units	6-9	6-9 (6-9)	6-9	6-9
	Suspended Solids	2970	15 (30)	15	15
	Oil & Grease	56	5 (10)	5	5
119	Chromium	3.9	0.1 (0.1)	0.1	0.1
120	Copper	3.9	0.1 (0.1)	0.1	0.1
122	Lead	2.1	0.1 (0.1)	0.1	0.1
124	Nickel	1.8	0.1 (0.2)	0.1	0.1
128	Zinc	4.4	0.1 (0.1)	0.1	0.1

---

(1) The flow for Model 2 is 3400 GPT. All other values apply to Models 1 and 2.
(2) Model 3 BAT feed values appear in parenthesis.

NOTE: All units mg/l unless otherwise noted.

SUBCATEGORY SUMMARY DATA
BASIS 7/1/78 DOLLARS

			Model Type		
			(1)	(2)	(3)
Subcategory:	Hot Forming	Model Size (TPD)	-	3000	1350
:	Primary	Operation (Days/Yr)	260	260	260
:	Specialty Without Scarfers	Turns/Day	3	3	3

Model Type	Model Applied Flow (MGD)	No. of Plants
1	-	0
2	6.9	1
3	3.1	14
		15

Total Flow (15 Plants) = 50.3 MGD

Model Costs	Model 3 BAT Feed	BAT 1			BAT 2		
		1	2	3	1	2	3
Investment Cost $ x 10^{-3}	998	-	2155	910	-	2366	937
Annual Cost $ x 10^{-3}	-92.0	-	435.9	176.9	-	475.7	182.4
$/Ton of Production	-0.26	-	0.56	0.50	-	0.61	0.52

	Wastewater Parameters	Raw Waste Levels	BAT Feed	BAT 1	BAT 2
	Flow (GPT)	2300	2300 (1150)(1)	90	90
	pH, Units	6-9	6-9 (6-9)	6-9	6-9
	Suspended Solids	2190	15 (30)	15	15
	Oil & Grease	84	5 (10)	5	5
119	Chromium	2.9	0.1 (0.1)	0.1	0.1
120	Copper	2.9	0.1 (0.1)	0.1	0.1
122	Lead	1.5	0.1 (0.1)	0.1	0.1
124	Nickel	4.9	0.1 (0.2)	0.1	0.1
128	Zinc	1.6	0.1 (0.1)	0.1	0.1

---

(1) Model 3 BAT feed values appear in parenthesis.

NOTE: All units mg/l unless otherwise noted.

SUBCATEGORY SUMMARY DATA
BASIS 7/1/78 DOLLARS

			Model Type		
			(1)	(2)	(3)
Subcategory:	Hot Forming	Model Size (TPD)	-	-	1350
:	Primary	Operation (Days/Yr)	260	260	260
:	Specialty With Scarfers	Turns/Day	3	3	3

Model Type	Model Applied Flow (MGD)	No. of Plants
1	-	0
2	-	0
3	4.6	3
		3

Total Flow (3 Plants) = 13.8 MGD

Model Costs	Model 3 BAT Feed	BAT 1			BAT 2		
		1	2	3	1	2	3
Investment Cost $ $x_3 10^{-3}$	1193	-	-	1150	-	-	1179
Annual Cost $ x 10^{-3}	-328.5	-	-	228.8	-	-	234.9
$/Ton of Production	-0.94	-	-	0.65	-	-	0.67

	Wastewater Parameters	Raw Waste Levels	BAT Feed	BAT 1	BAT 2
	Flow (GPT)	3400	1700	140	140
	pH, Units	6-9	6-9	6-9	6-9
	Suspended Solids	2970	30	15	15
	Oil & Grease	56	10	5	5
119	Chromium	3.9	0.1	0.1	0.1
120	Copper	3.9	0.1	0.1	0.1
122	Lead	2.1	0.1	0.1	0.1
124	Nickel	6.6	0.2	0.1	0.1
128	Zinc	2.2	0.1	0.1	0.1

NOTE: All units mg/l unless otherwise noted.

SUBCATEGORY SUMMARY DATA
BASIS 7/1/78 DOLLARS

Subcategory: Hot Forming
: Section
: Carbon

	Model Type (1)	Model Type (2)	Model Type (3)
Model Size (TPD)	970	3340	2900
Operation (Days/Yr)	260	260	260
Turns/Day	3	3	3

Model Type	Model Applied Flow (MGD)	No. of Plants
1	5.0	2
2	17.0	12
3	14.8	52
		66

Total Flow (66 Plants) = 983.6 MGD

Model Costs	Model 3 BAT Feed	BAT 1			BAT 2		
		1	2	3	1	2	3
Investment Cost $ x 10^{-3}	2138	1018	3823	2531	1182	4205	2572
Annual Cost $ x 10^{-3}	-208.6	204.5	791.1	510.6	235.3	864.2	520.7
$/Ton of Production	-0.28	0.81	0.91	0.68	0.93	1.0	0.69

	Wastewater Parameters	Raw Waste Levels	BAT Feed	BAT 1	BAT 2
	Flow (GPT)	5100	2550$^{(1)}$ (2550)$^{(2)}$	200	200
	pH, Units	6-9	6-9 (6-9)	6-9	6-9
	Suspended Solids	990	15 (30)	15	15
	Oil & Grease	38	5 (10)	5	5
119	Chromium	1.3	0.1 (0.1)	0.1	0.1
120	Copper	1.3	0.1 (0.1)	0.1	0.1
122	Lead	0.7	0.1 (0.1)	0.1	0.1
124	Nickel	0.6	0.1 (0.2)	0.1	0.1
128	Zinc	1.5	0.1 (0.1)	0.1	0.1

---

(1) The flow for Model 2 is 5100 GPT. All other values apply to Models 1 and 2.
(2) Model 3 BAT feed values appear in parenthesis.

NOTE: All units mg/l unless otherwise noted.

SUBCATEGORY SUMMARY DATA
BASIS 7/1/78 DOLLARS

			Model Type		
			(1)	(2)	(3)
Subcategory:	Hot Forming	Model Size (TPD)	1600	1800	1400
:	Section	Operation (Days/Yr)	260	260	260
:	Specialty	Turns/Day	3	3	3

Model Type	Model Applied Flow (MGD)	No. of Plants
1	5.1	1
2	5.8	3
3	4.5	15
		19

Total Flow (19 Plants) = 90.0 MGD

Model Costs	Model 3 BAT Feed	BAT 1			BAT 2		
		1	2	3	1	2	3
Investment Cost \$ x 10^{-3}	1139	1018	1701	1146	1182	1938	1173
Annual Cost \$ x 10^{-3}	-78.9	204.5	343.5	228.0	235.3	387.5	233.8
\$/Ton of Production	-0.22	0.49	0.73	0.63	0.57	0.83	0.64

	Wastewater Parameters	Raw Waste Levels	BAT Feed	BAT 1	BAT 2
	Flow (GPT)	3200	1600(1) (1600)(2)	130	130
	pH, Units	6-9	6-9 (6-9)	6-9	6-9
	Suspended Solids	1580	15 (30)	15	15
	Oil & Grease	60	5 (10)	5	5
119	Chromium	2.1	0.1 (0.1)	0.1	0.1
120	Copper	2.1	0.1 (0.1)	0.1	0.1
122	Lead	1.1	0.1 (0.1)	0.1	0.1
124	Nickel	3.5	0.1 (0.2)	0.1	0.1
128	Zinc	1.2	0.1 (0.1)	0.1	0.1

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(1) The flow for Model 2 is 3200 GPT. All other values apply to Models 1 and 2.
(2) Model 3 BAT feed values appear in parenthesis.

NOTE: All units mg/l unless otherwise noted.

SUBCATEGORY SUMMARY DATA
BASIS 7/1/78 DOLLARS

Subcategory: Hot Forming
: Flat
: Hot Strip & Sheet
: Carbon-Specialty

	Model Type (1)	Model Type (2)	Model Type (3)
Model Size (TPD)	13,200	5900	5800
Operation (Days/Yr)	260	260	260
Turns/Day	3	3	3

Model Type	Model Applied Flow (MGD)	No. of Plants
1	84.5	2
2	37.8	5
3	37.1	35
		42

Total Flow (42 Plants) = 1656.5 MGD

Model Costs	Model 3 BAT Feed	BAT 1			BAT 2		
		1	2	3	1	2	3
Investment Cost $ x 10^{-3}	6088	7495	5754	5259	8488	6372	5316
Annual Cost $ x 10^{-3}	454.7	1683	1268.4	1120.1	1890.5	1389.2	1137.3
$/Ton of Production	0.30	0.49	0.83	0.74	0.55	0.91	0.75

Wastewater Parameters		Raw Waste Levels	BAT Feed	BAT 1	BAT 2
	Flow (GPT)	6400	4480(1) (4480)(2)	260	260
	pH, Units	6-9	6-9 (6-9)	6-9	6-9
	Suspended Solids	790	15 (30)	15	15
	Oil & Grease	30	5 (10)	5	5
119	Chromium	1.0	0.1 (0.1)	0.1	0.1
120	Copper	1.0	0.1 (0.1)	0.1	0.1
122	Lead	0.5	0.1 (0.1)	0.1	0.1
124	Nickel	1.1	0.1 (0.2)	0.1	0.1
128	Zinc	0.9	0.1 (0.1)	0.1	0.1

---

(1) The flow for Model 2 is 6400 GPT. All other values apply to Models 1 and 2.
(2) Model 3 BAT feed values appear in parenthesis.

NOTE: All units mg/l unless otherwise noted.

SUBCATEGORY SUMMARY DATA
BASIS 7/1/78 DOLLARS

Subcategory: Hot Forming
: Flat
: Plate
: Carbon

	Model Type		
	(1)	(2)	(3)
Model Size (TPD)	-	6900	2800
Operation (Days/Yr)	260	260	260
Turns/Day	3	3	3

Model Type	Model Applied Flow (MGD)	No. of Plants
1	-	0
2	23.5	2
3	9.5	10
		12

Total Flow (12 Plants) = 142.0 MGD

Model Costs	Model 3 BAT Feed	BAT 1			BAT 2		
		1	2	3	1	2	3
Investment Cost \$ x 10^{-3}	2005	-	4481	2310	-	4945	2344
Annual Cost \$ x 10^{-3}	134.3	-	966.3	464.9	-	1055.6	472.9
\$/Ton of Production	0.18	-	0.54	0.64	-	0.59	0.65

	Wastewater Parameters	Raw Waste Levels	BAT Feed	BAT 1	BAT 2
	Flow (GPT)	3400	3400(1) (2380)(2)	140	140
	pH, Units	6-9	6-9 (6-9)	6-9	6-9
	Suspended Solids	1480	15 (30)	15	15
	Oil & Grease	56	5 (10)	5	5
119	Chromium	1.9	0.1 (0.1)	0.1	0.1
120	Copper	1.9	0.1 (0.1)	0.1	0.1
122	Lead	1.0	0.1 (0.1)	0.1	0.1
124	Nickel	0.9	0.1 (0.2)	0.1	0.1
128	Zinc	2.2	0.1 (0.1)	0.1	0.1

---

(1) Model 3 BAT feed values appear in parenthesis.

NOTE: All units mg/l unless otherwise noted.

SUBCATEGORY SUMMARY DATA
BASIS 7/1/78 DOLLARS

Subcategory: Hot Forming
: Flat
: Plate
: Specialty

	Model Type		
	(1)	(2)	(3)
Model Size (TPD)	-	3600	220
Operation (Days/Yr)	260	260	260
Turns/Day	3	3	3

Model Type	Model Applied Flow (MGD)	No. of Plants
1	-	0
2	5.4	1
3	0.33	3
		4

Total Flow (4 Plants) = 6.4 MGD

Model Costs	Model 3 BAT Feed	BAT 1			BAT 2		
		1	2	3	1	2	3
Investment Cost $\$ \times 10^{-3}$	367.4	-	1659	318	-	1883	339
Annual Cost $\$ \times 10^{-3}$	49.3	-	336.1	60.4	-	377.9	64.3
$/Ton of Production	0.86	-	0.36	1.06	-	0.40	1.12

	Wastewater Parameters	Raw Waste Levels	BAT Feed	BAT 1	BAT 2
	Flow (GPT)	1500	1500 (1050)(1)	60	60
	pH, Units	6-9	6-9 (6-9)	6-9	6-9
	Suspended Solids	3360	15 (30)	15	15
	Oil & Grease	130	5 (10)	5	5
119	Chromium	4.4	0.1 (0.1)	0.1	0.1
120	Copper	4.4	0.1 (0.1)	0.1	0.1
122	Lead	2.3	0.1 (0.1)	0.1	0.1
124	Nickel	7.4	0.1 (0.2)	0.1	0.1
128	Zinc	2.5	0.1 (0.1)	0.1	0.1

---

(1) Model 3 BAT feed values appear in parenthesis.

NOTE: All units mg/l unless otherwise noted.

SUBCATEGORY SUMMARY DATA
BASIS 7/1/78 DOLLARS

Subcategory: Hot Forming
: Pipe & Tube
: Carbon

	Model Type		
	(1)	(2)	(3)
Model Size (TPD)	822	547	1036
Operation (Days/Yr)	260	260	260
Turns/Day	3	3	3

Model Type	Model Applied Flow (MGD)	No. of Plants
1	4.5	1
2	3.0	3
3	5.7	20
		24

Total Flow (24 Plants) = 127.4 MGD

Model Costs	Model 3 BAT Feed	BAT 1			BAT 2		
		1	2	3	1	2	3
Investment Cost $ x 10^{-3}	1589	740	1167	1327	903	1311	1359
Annual Cost $ x 10^{-3}	-131.0	155.0	233.9	263.1	185.6	260.6	269.9
$/Ton of Production	-0.49	0.73	1.64	0.98	0.87	1.83	1.00

Wastewater Parameters		Raw Waste Levels	BAT Feed	BAT 1	BAT 2
	Flow (GPT)	5520	2760(1) (2760)(2)	220	220
	pH, Units	6-9	6-9 (6-9)	6-9	6-9
	Suspended Solids	210	15 (30)	15	15
	Oil & Grease	35	5 (10)	5	5
119	Chromium	1.2	0.1 (0.1)	0.1	0.1
120	Copper	1.2	0.1 (0.1)	0.1	0.1
122	Lead	0.6	0.1 (0.1)	0.1	0.1
124	Nickel	0.6	0.1 (0.2)	0.1	0.1
128	Zinc	1.3	0.1 (0.1)	0.1	0.1

---

(1) The flow for Model 2 is 5520 GPT. All other values apply to Models 1 and 2.

(2) Model 3 BAT feed values appear in parenthesis.

NOTE: All units mg/l unless otherwise noted.

SUBCATEGORY SUMMARY DATA
BASIS 7/1/78 DOLLARS

Subcategory: Hot Forming
: Pipe & Tube
: Specialty

	Model Type (1)	Model Type (2)	Model Type (3)
Model Size (TPD)	-	1195	338
Operation (Days/Yr)	260	260	260
Turns/Day	3	3	3

Model Type	Model Applied Flow (MGD)	No. of Plants
1	-	0
2	6.6	1
3	1.9	5
		6

Total Flow (6 Plants) = 16.1 MGD

Model Costs	Model 3 BAT Feed	BAT 1 1	BAT 1 2	BAT 1 3	BAT 2 1	BAT 2 2	BAT 2 3
Investment Cost $ x 10^{-3}	871.4	-	2060	650	-	2271	675
Annual Cost $ x 10^{-3}	19.4	-	419.0	125.3	-	458.8	130.2
$/Ton of Production	0.22	-	1.35	1.43	-	1.48	1.48

Wastewater Parameters	Raw Waste Levels	BAT Feed	BAT 1	BAT 2
Flow (GPT)	5520	5520 (2760)(1)	220	220
pH, Units	6-9	6-9 (6-9)	6-9	6-9
Suspended Solids	910	15 (30)	15	15
Oil & Grease	35	5 (10)	5	5
119 Chromium	1.2	0.1 (0.1)	0.1	0.1
120 Copper	1.2	0.1 (0.1)	0.1	0.1
122 Lead	0.6	0.1 (0.1)	0.1	0.1
124 Nickel	2.0	0.1 (0.2)	0.1	0.1
128 Zinc	0.7	0.1 (0.1)	0.1	0.1

---

(1) Model 3 BAT feed values appear in parenthesis.

NOTE: All units mg/l unless otherwise noted.

SUMMARY OF EFFLUENT LOADINGS (TONS/YEAR) AND TREATMENT COSTS
HOT FORMING SUBCATEGORY

	Raw Waste Load	BAT Feed	BAT-1	BAT-2
Flow (MGD)	4,188	2,670	167.5	167.5
TSS and Oil and Grease	6,289,895	101,822	3632.1	3632.1
Toxic Metals	34,820	1,670	90.8	90.8
Toxic Organics	(1)	(1)	(1)	(1)

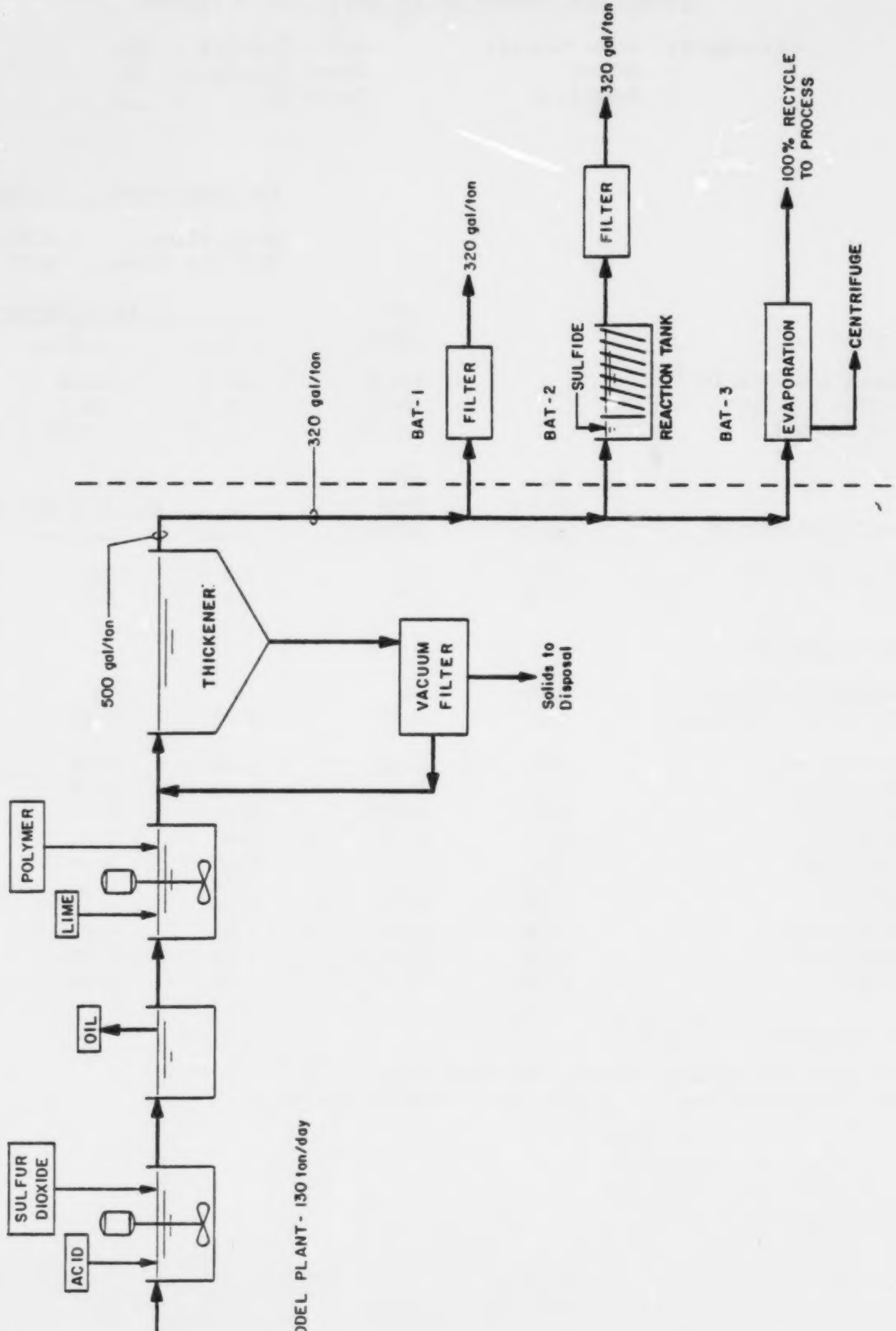
OPTION COST
(MILLIONS OF DOLLARS)

Subcategory Costs	BAT Feed	BAT-1	BAT-2
Investment	676.96	535.50	554.30
Annual	-103.70	110.80	114.80

---

(1) No toxic organic pollutants were found at average concentrations greater than 10 ppb.

KOLENE SCALE REMOVAL TREATMENT OPTIONS


BPT
MODEL PLANT - 130 ton/day
ACID
SULFUR DIOXIDE
OIL
LIME
POLYMER
THICKENER
500 gal/ton
VACUUM FILTER
Solids to Disposal
320 gal/ton
BAT-1
FILTER
320 gal/ton
BAT-2
SULFIDE
REACTION TANK
FILTER
320 gal/ton
BAT-3
EVAPORATION
CENTRIFUGE
100% RECYCLE TO PROCESS

SUBCATEGORY SUMMARY DATA: BASIS 7/1/78 DOLLARS

Subcategory:	Scale Removal	Model Size-TPD :	130
:	Kolene	Oper. Days/Year:	250
:	Specialty	Turns/Day :	2

Raw Waste Flows	(MGD)
Model Plant:	0.042
19 Plant Sites:	0.79

Model Costs	BAT Feed	BAT Alternatives 1	2	3
Investment Cost $ x 10^{-3}	506.0	140.0	182.0	2035.7
Annual Cost $ x 10^{-3}	96.2	25.1	32.7	461.9
$/Ton of Product(1)	2.96	0.77	1.01	14.21

Wastewater Parameters	Raw Waste Level	BAT Feed Level	BAT Effluent Levels 1	2	3
Flow, gal/ton	320	320	320	320	0
pH	8-12	6-9	6-9	6-9	-
Concentrations (mg/1)					
Suspended Solids	1200	25	15	15	-
Hexavalent Chromium	400	0.05	0.05	0.05	-
23 Chloroform	0.03	0.03	0.03	0.03	-
114 Antimony*	0.10	0.10	0.10	0.10	-
115 Arsenic*	0.025	0.025	0.025	0.025	-
118 Cadmium*	0.01	0.01	0.01	0.01	-
119 Chromium*	450	0.50	0.10	0.10	-
120 Copper*	2.00	0.50	0.10	0.10	-
124 Nickel*	2.00	0.50	0.10	0.10	-
125 Selenium*	0.06	0.06	0.06	0.06	-
127 Thallium*	0.20	0.20	0.10	0.10	-
128 Zinc*	0.10	0.10	0.10	0.10	-

---

(1) BAT costs are incremental over BAT Feed costs.

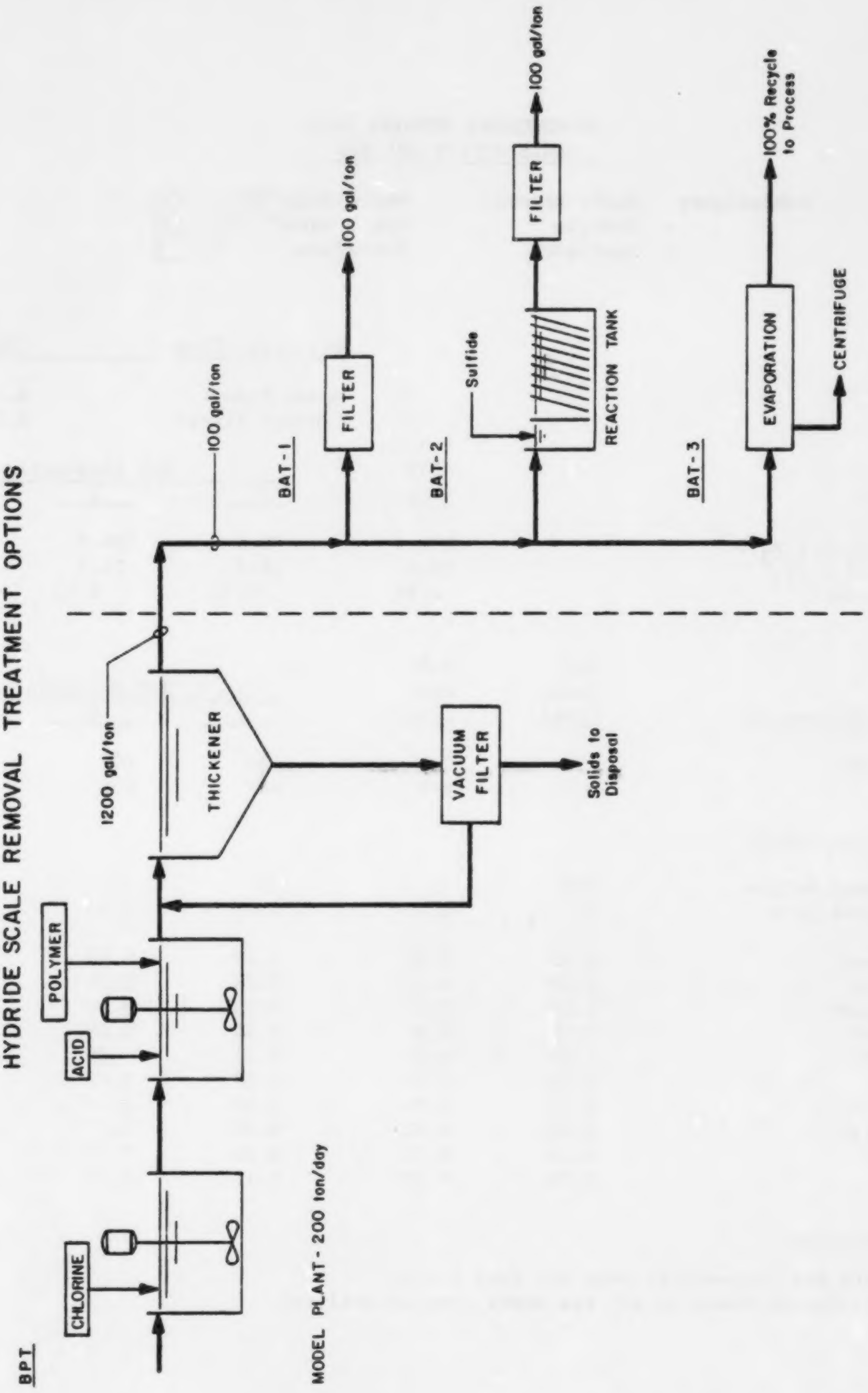
* Toxic pollutant found in all raw waste samples analyzed.

SUMMARY OF EFFLUENT LOADINGS (TONS/YEAR) AND TREATMENT COSTS
KOLENE SCALE REMOVAL

	Raw Waste Load	BAT Feed	BAT-1	BAT-2	BAT-3
Flow (MGD)	0.80	0.80	0.80	0.80	0
TSS	1003.58	20.91	12.54	12.54	-
Hex Chromium	334.53	0.04	0.04	0.04	-
Toxic Metals	380.11	1.67	0.59	0.59	-
Toxic Organics	0.025	0.02	0.02	0.02	-

OPTION COSTS
(MILLIONS OF DOLLARS)

	BAT Feed	BAT-1	BAT-2	BAT-3
Model Plant (130 TPD)				
Capital	0.43	0.14	0.18	2.036
Annual	0.083	0.03	0.033	0.46
Subcategory (19 Plants)				
Capital	8.17	2.66	3.42	38.68
Annual	1.58	0.57	0.63	8.74



HYDRIDE SCALE REMOVAL TREATMENT OPTIONS

BPT
CHLORINE
ACID
POLYMER
1200 gal/ton
THICKENER
VACUUM FILTER
Solids to Disposal
MODEL PLANT - 200 ton/day
100 gal/ton
BAT-1
FILTER
100 gal/ton
BAT-2
Sulfide
REACTION TANK
FILTER
100 gal/ton
BAT-3
EVAPORATION
CENTRIFUGE
100% Recycle to Process

SUBCATEGORY SUMMARY DATA
BASIS 7/1/78 DOLLARS

Subcategory:	Scale Removal	Model Size-TPD :	200
:	Hydride	Oper. Days/Year:	270
:	Specialty	Turns/Day :	3

Raw Waste Flows	(MGD)
Model Plant:	0.020
6 Plant Sites:	0.12

Model Costs	BAT Feed	BAT Alternatives 1	2	3
Investment Cost $ x 10^{-3}	290.0	94.0	124.0	934.5
Annual Cost $ x 10^{-3}	53.4	16.9	22.5	169.8
$/Ton of Product(1)	0.99	0.31	0.42	3.14

Wastewater Parameters	Raw Waste Level	BAT Feed Level	BAT Effluent Level 1	2	3
Flow, gal/ton	100	100	100	100	0
pH	8-12	6-9	6-9	6-9	-
Concentrations (mg/1)					
Suspended Solids	500	25	15	15	-
Dissolved Iron	40	1.00	0.20	0.20	-
114 Antimony	0.80	0.80	0.20	0.10	-
118 Cadmium	0.10	0.10	0.05	0.05	-
119 Chromium*	5.00	0.50	0.10	0.10	-
120 Copper*	0.75	0.50	0.10	0.10	-
121 Cyanide	1.00	0.25	0.25	0.25	-
122 Lead	1.00	0.50	0.20	0.10	-
124 Nickel*	5.00	0.50	0.10	0.10	-
125 Selenium	0.025	0.02	0.02	0.02	-
126 Silver	0.10	0.10	0.10	0.10	-
128 Zinc	0.20	0.20	0.10	0.10	-

---

(1) BAT costs are incremental over BAT Feed costs.

* Toxic pollutant found in all raw waste samples analyzed.

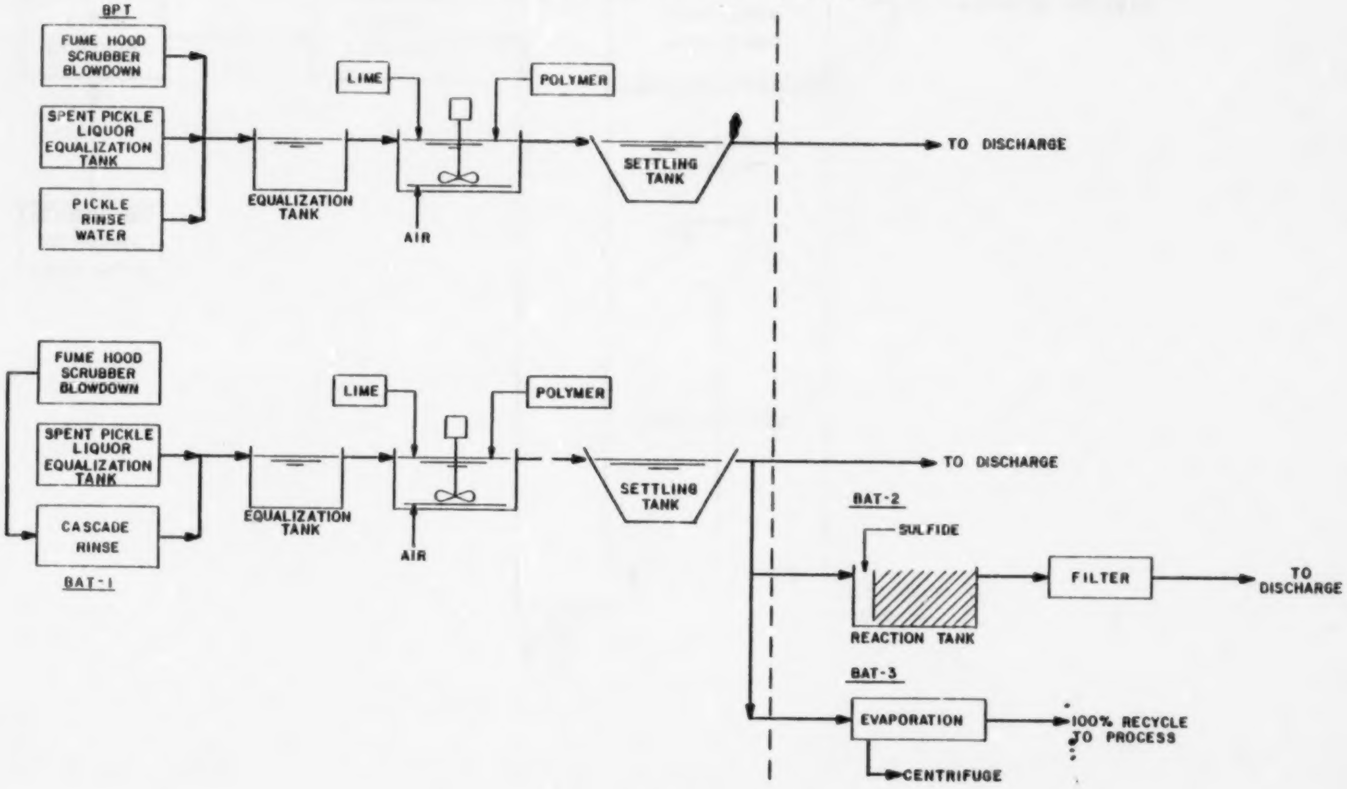
SUMMARY OF EFFLUENT LOADINGS (TONS/YEAR) AND TREATMENT COSTS
HYDRIDE SCALE REMOVAL

	Raw Waste Load	BAT Feed	BAT-1	BAT-2	BAT-3
Flow (MGD)	0.12	0.12	0.12	0.12	0
TSS	67.55	3.38	2.03	2.03	-
Toxic Metals	1.75	0.44	0.14	0.10	-
Toxic Organics	0.14	0.03	0.03	0.03	-

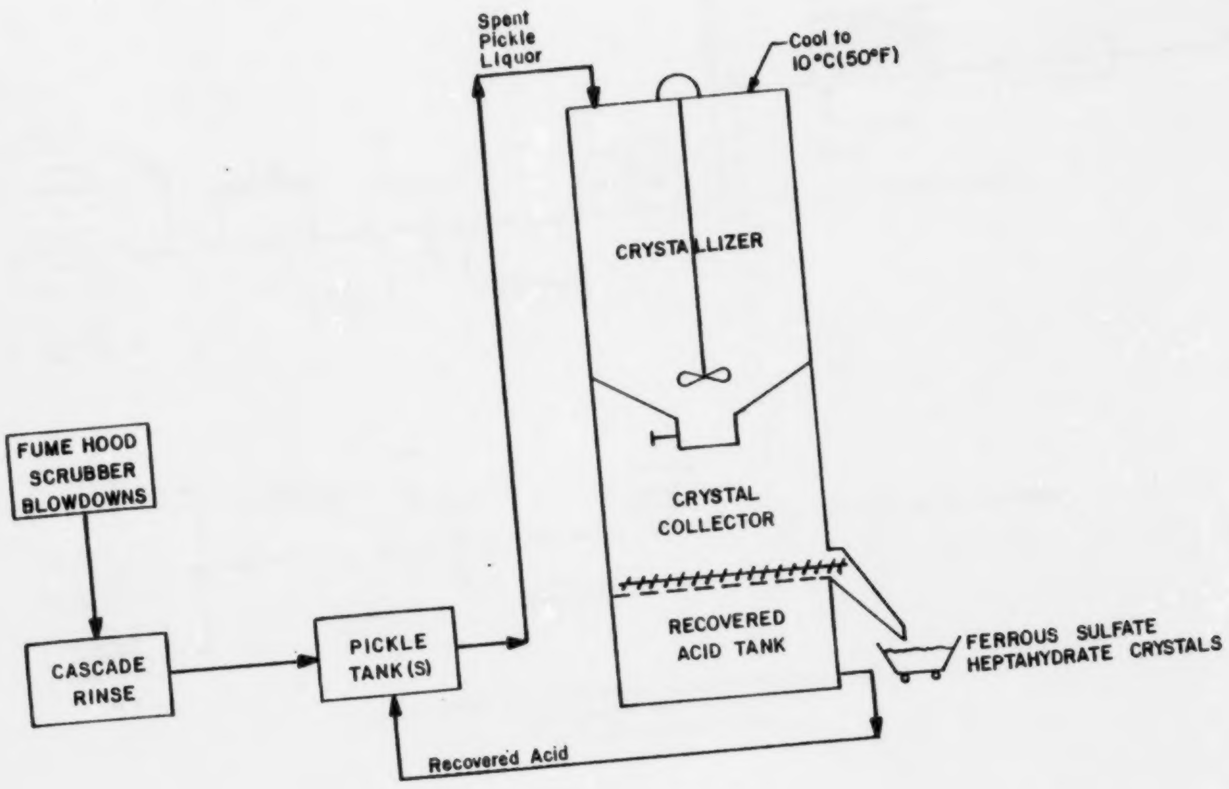
OPTION COSTS
(MILLIONS OF DOLLARS)

	BAT Feed	BAT-1	BAT-2	BAT-3
Model Plant (200 TPD)				
Capital	0.29	0.094	0.012	0.93
Annual	0.053	0.017	0.0023	0.17
Subcategory (6 Plants)				
Capital	1.74	0.56	0.74	5.61
Annual	0.32	0.10	0.14	1.02

SULFURIC ACID PICKLING
TREATMENT MODELS SUMMARY
BATCH AND CONTINUOUS NEUTRALIZATION SYSTEMS


BPT
FUME HOOD SCRUBBER BLOWDOWN
SPENT PICKLE LIQUOR EQUALIZATION TANK
PICKLE RINSE WATER
EQUALIZATION TANK
LIME
POLYMER
AIR
SETTLING TANK
TO DISCHARGE
FUME HOOD SCRUBBER BLOWDOWN
SPENT PICKLE LIQUOR EQUALIZATION TANK
CASCADE RINSE
BAT-1
EQUALIZATION TANK
LIME
POLYMER
AIR
SETTLING TANK
TO DISCHARGE
BAT-2
SULFIDE
REACTION TANK
FILTER
TO DISCHARGE
BAT-3
EVAPORATION
100% RECYCLE TO PROCESS
CENTRIFUGE

SULFURIC ACID PICKLING
TREATMENT MODELS SUMMARY
BATCH AND CONTINUOUS ACID RECOVERY SYSTEMS


Spent
Pickle
Liquor
Cool to
10°C(50°F)
CRYSTALLIZER
CRYSTAL
COLLECTOR
RECOVERED
ACID TANK
FERROUS SULFATE
HEPTAHYDRATE CRYSTALS
FUME HOOD
SCRUBBER
BLOWDOWNS
CASCADE
RINSE
PICKLE
TANK (S)
Recovered Acid

SUBCATEGORY SUMMARY DATA
BASIS 7/1/78 DOLLARS

Subcategory:	Sulfuric Acid Pickling	Model Size-TPD :	500
:	Batch Type	Oper. Days/Year:	260
:	Carbon & Specialty	Turns/Day :	3

Raw Waste Flows	(MGD)
Model Plant:	0.53

No. of Plants: 95
  Neutralization in Place: 59
  Acid Recovery in Place: 4
  No Treatment (Acid Recovery Required): 32
Total Flow for Subcategory: 50.4 MGD

Model Costs ($ x 10^{-3})	BAT Feed	BAT Alternatives 1	BAT Alternatives 2	BAT Alternatives 3
Neutralization System:				
Investment Cost	7870.0	63.0	164.0	1413.0
Annual Cost	174.9	19.5	38.0	271.9
$/Ton of Product(1)	1.35	0.15	0.29	2.09
Acid Recovery System:				
Investment Cost	2781.0	No additional treatment is necessary. BPT achieved zero discharge.		
Annual Cost	489.6			
$/Ton of Product	3.77			

	Wastewater Parameter	Raw Waste Level Conc.	Raw Waste Level Rinse	Raw Waste Level FHS	Total	BAT Feed(2) Level	BAT Effluent Level(2) 1	BAT Effluent Level(2) 2	BAT Effluent Level(2) 3
	Flow, gal/ton	20	380	710	1060	360	70	70	0
	pH, units	<1	1-6	1.4-1.9	<1-6	6-9	6-9	6-9	-
	Concentrations (mg/l)								
	Suspended Solids	870	420	70	195	30	30	15	-
	Dissolved Iron	56,000	5400	130	2800	1.0	1.0	1.0	-
	Oil & Grease	150	65	4.5	26	10	10	5	-
115	Arsenic	0.20	0.40	-	0.40	0.10	0.10	0.10	-
118	Cadmium*	0.80	0.80	-	0.80	0.10	0.10	0.10	-
119	Chromium*	240	5.1	-	18.5	0.10	0.10	0.10	-
120	Copper*	3.7	1.2	-	1.3	0.10	0.10	0.10	-
122	Lead	0.80	0.30	-	0.50	0.10	0.10	0.10	-
124	Nickel*	25	2.0	-	3.3	0.20	0.20	0.10	-
128	Zinc*	75	21	-	24	0.10	0.10	0.10	-

---

(1) BAT costs are incremental over BAT Feed costs.

(2) Levels for neutralization systems only. Acid recovery systems achieve zero discharge at these levels.

*: Toxic pollutant found in all raw waste samples analyzed.

SUBCATEGORY SUMMARY DATA
BASIS 7/1/78 DOLLARS

Subcategory:	Sulfuric Acid Pickling	Model Size-TPD :	1980
:	Continuous Type	Oper. Days/Year:	260
:	Carbon & Specialty	Turns/Day :	3

Raw Waste Flows (MGD)

Model Plant: 0.73

No. of Plants: 32
  Neutralization in Place: 19
  Acid Recovery in Place: 2
  No Treatment (Acid Recovery Required): 11
Total Flow for Subcategory: 23.4 MGD

Model Costs (\$ x 10^{-3})	BAT Feed	BAT Alternatives 1	2	3
Neutralization System:				
Investment Cost	1421.0	293.0	470.0	2329.0
Annual Cost	397.7	91.1	124.3	577.0
\$/Ton of Product(1)	0.77	0.18	0.24	1.12
Acid Recovery System:				
Investment Cost	5549.0	No additional treatment is necessary. BPT achieved zero discharge.		
Annual Cost	977.0			
\$/Ton of Product	1.90			

Wastewater Parameter	Raw Waste Level				BAT Feed(2) Level	BAT Effluent Level(2)		
	Conc.	Rinse	FHS	Total		1	2	3
Flow, gal/ton	20	220	130	370	250	55	55	0
pH, units	<1	2-6	1.4-1.7	<1-6	6-9	6-9	6-9	-
Concentrations (mg/l)								
Suspended Solids	2600	120	70	236	30	30	15	-
Dissolved Iron	45,000	6100	130	6100	1.0	1.0	1.0	-
Oil & Grease	18	12	4.5	10	10	10	5	-
115 Arsenic*	0.20	0.07	-	0.10	0.10	0.10	0.10	-
118 Cadmium*	0.50	0.10	-	0.10	0.10	0.10	0.10	-
119 Chromium*	30	0.70	-	3.1	0.10	0.10	0.10	-
120 Copper*	3.0	0.90	-	1.1	0.10	0.10	0.10	-
122 Lead*	1.6	0.35	-	0.45	0.10	0.10	0.10	-
124 Nickel*	21	4.6	-	6.0	0.20	0.20	0.10	-
128 Zinc*	3.0	0.65	-	0.85	0.10	0.10	0.10	-

---

(1) BAT costs are incremental over BAT Feed costs.
(2) Levels for neutralization systems only. Acid recovery systems achieve zero discharge at these levels.
*: Toxic pollutant found in all raw waste samples analyzed.

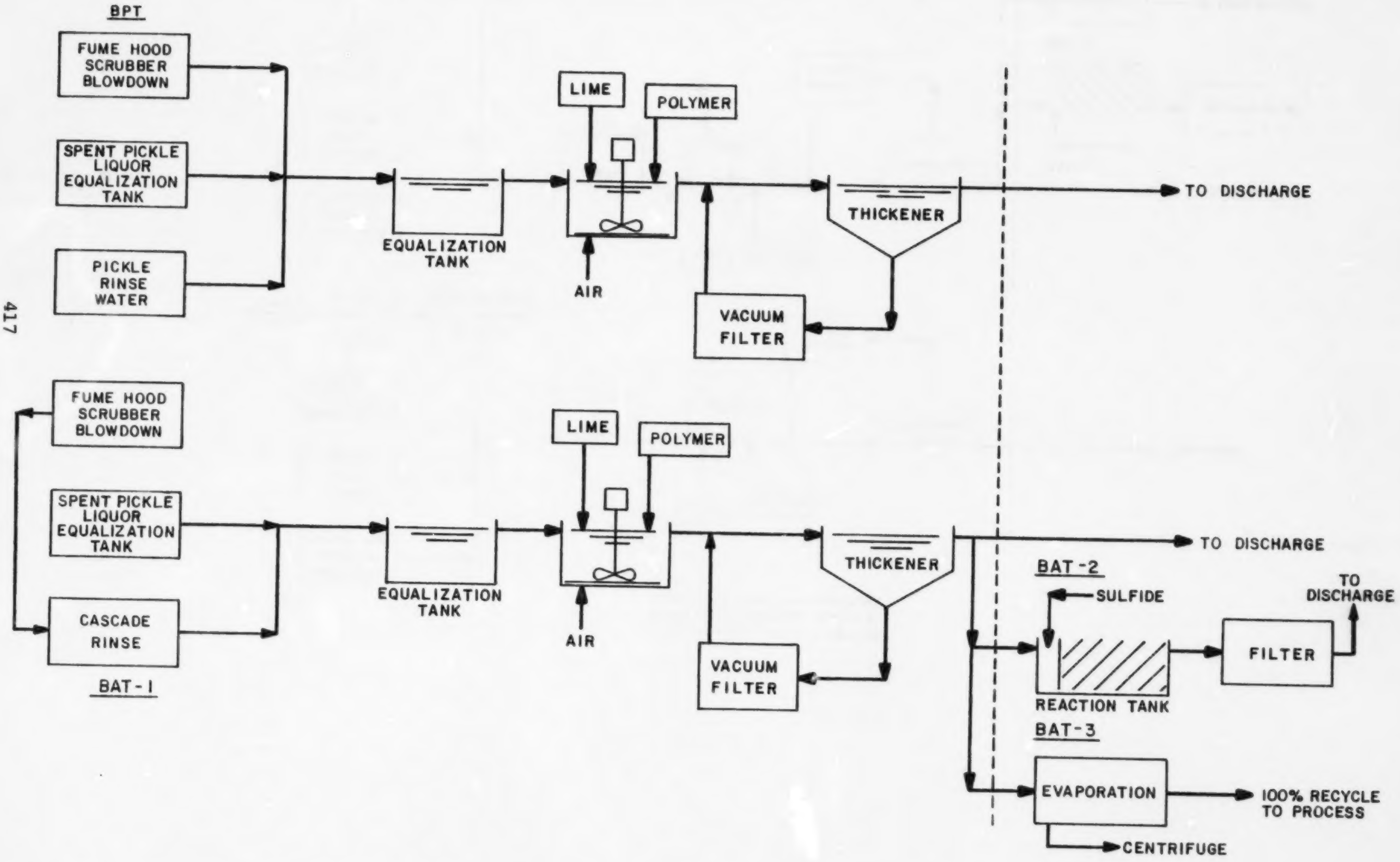
SUMMARY OF EFFLUENT LOADINGS (TONS/YEAR) AND TREATMENT COSTS
SULFURIC ACID PICKLING SUBCATEGORY

	Raw Waste Load	BAT Feed	BAT-1	BAT-2	BAT-3
Flow (MGD)	73.8	32.9	6.8	6.8	0
TSS	16,643	1071	221	110.7	-
Oil and Grease	1,673	357	73.8	36.9	-
Toxic Metals	2,936	28.5	5.9	5.1	-
Toxic Organics	-	-	-	-	-
Dissolved Iron	307,894	35.7	7.4	7.4	-

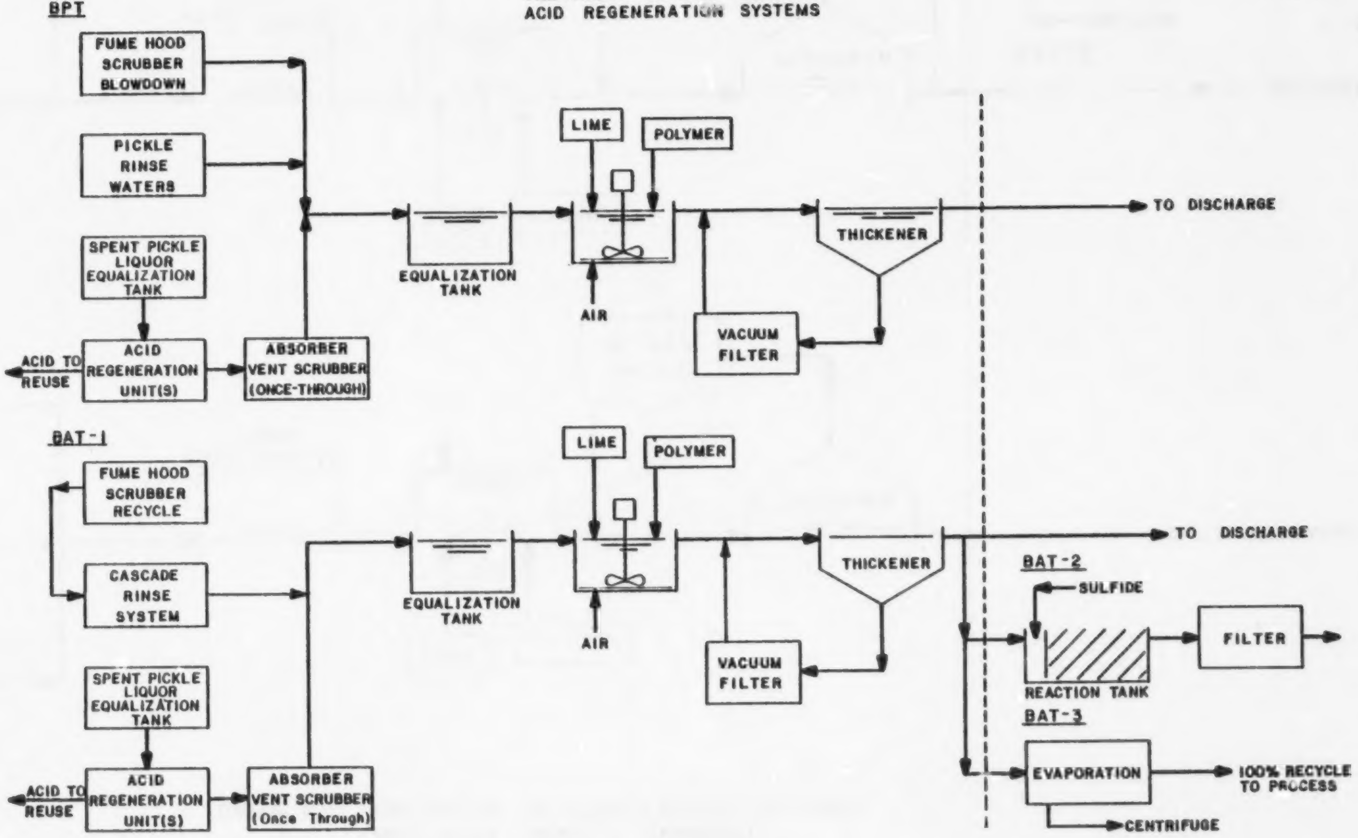
OPTION COSTS
(MILLIONS OF DOLLARS)

Model Plant	BAT Feed	BAT-1	BAT-2	BAT-3
Continuous Operations (1980 TPD)				
Neutralization System - Capital	1.42	0.29	0.47	2.33
- Annual	0.40	0.09	0.12	0.58
Acid Recovery System - Capital	5.55	-	-	-
- Annual	0.98	-	-	-
Batch Operations (500 TPD)				
Neutralization System - Capital	0.79	0.06	0.16	1.41
- Annual	0.17	0.02	0.04	0.27
Acid Recovery System - Capital	2.78	-	-	-
- Annual	0.49	-	-	-
Sulfuric Acid Pickling Subcategory				
Continuous - Neutralization - Capital	26.98	5.51	8.93	44.27
19 Plants - Annual	7.60	1.71	2.28	11.02
Continuous - Acid Recovery - Capital	72.15	-	-	-
13 Plants - Annual	12.74	-	-	-
Batch - Neutralization - Capital	46.61	3.54	9.44	83.19
59 Plants - Annual	10.03	1.18	2.36	15.93
Batch - Acid Recovery - Capital	100.08	-	-	-
36 Plants - Annual	17.64	-	-	-
Total for Subcategory - Capital	245.82	9.05	18.37	127.46
127 Plants - Annual	48.01	2.89	4.64	26.95

HYDROCHLORIC ACID PICKLING
TREATMENT MODELS SUMMARY
BATCH AND CONTINUOUS NEUTRALIZATION SYSTEMS


BPT
FUME HOOD SCRUBBER BLOWDOWN
SPENT PICKLE LIQUOR EQUALIZATION TANK
PICKLE RINSE WATER
EQUALIZATION TANK
LIME
POLYMER
AIR
VACUUM FILTER
THICKENER
TO DISCHARGE
FUME HOOD SCRUBBER BLOWDOWN
SPENT PICKLE LIQUOR EQUALIZATION TANK
CASCADE RINSE
BAT-1
EQUALIZATION TANK
LIME
POLYMER
AIR
VACUUM FILTER
THICKENER
TO DISCHARGE
BAT-2
SULFIDE
REACTION TANK
FILTER
TO DISCHARGE
BAT-3
EVAPORATION
100% RECYCLE TO PROCESS
CENTRIFUGE

HYDROCHLORIC ACID PICKLING
TREATMENT MODELS SUMMARY
ACID REGENERATION SYSTEMS


BPT
FUME HOOD SCRUBBER BLOWDOWN
PICKLE RINSE WATERS
SPENT PICKLE LIQUOR EQUALIZATION TANK
ACID TO REUSE
ACID REGENERATION UNIT(S)
ABSORBER VENT SCRUBBER (ONCE-THROUGH)
EQUALIZATION TANK
LIME
POLYMER
AIR
VACUUM FILTER
THICKENER
TO DISCHARGE
BAT-1
FUME HOOD SCRUBBER RECYCLE
CASCADE RINSE SYSTEM
SPENT PICKLE LIQUOR EQUALIZATION TANK
ACID TO REUSE
ACID REGENERATION UNIT(S)
ABSORBER VENT SCRUBBER (Once Through)
EQUALIZATION TANK
LIME
POLYMER
AIR
VACUUM FILTER
THICKENER
TO DISCHARGE
BAT-2
SULFIDE
REACTION TANK
FILTER
BAT-3
EVAPORATION
100% RECYCLE TO PROCESS
CENTRIFUGE

SUBCATEGORY SUMMARY DATA
BASIS 7/1/78 DOLLARS

Subcategory:	Hydrochloric Acid Pickling	Model Size-TPD :	190
:	Batch Type	Oper. Days/Year:	260
:	Carbon & Specialty	Turns/Day :	2

Raw Waste Flows	(MGD)
Model Plant:	0.13

No. of Plants: 7 Total
Total Flow for Batch HCl Pickling: 0.93 MGD

Model Costs ($ x 10^{-3})	BAT Feed	BAT Alternatives 1	BAT Alternatives 2	BAT Alternatives 3
Investment Cost	1223	63.0	164.0	1413.0
Annual Cost	250.8	19.5	38.0	271.9
$/Ton of Product(1)	5.07	0.39	0.77	5.50

Wastewater Parameters	Raw Waste Level				BAT Feed Level	BAT Effluent Level		
	Conc	Rinse	FHS	Total		1	2	3
Flow, gal/ton	10	540	150	700	560	90	90	-
pH, Units	<1-5	1-5	<1-3.7	<1-5	6-9	6-9	6-9	-
Concentrations(mg/l)								
Suspended Solids	450	90	370	155	30	30	15	-
Dissolved Iron	57,000	2700	820	3100	1.0	1.0	1.0	-
Oil & Grease	44	33	66	40	10	10	5	-
23 Chloroform	0.03	0.01	0.10	0.03	0.01	<0.01	<0.01	-
114 Antimony*	2.2	0.01	0.40	0.10	0.10	0.10	0.10	-
115 Arsenic*	0.20	0.09	0.05	0.10	0.10	0.10	0.10	-
118 Cadmium*	0.20	0.04	0.06	0.10	0.10	0.10	0.10	-
119 Chromium*	13	0.35	0.35	0.50	0.10	0.10	0.10	-
120 Copper*	13	0.60	0.80	0.80	0.10	0.10	0.10	-
122 Lead*	310	18	0.30	18	0.10	0.10	0.10	-
124 Nickel*	10	0.50	0.55	0.60	0.20	0.20	0.10	-
126 Silver*	0.20	0.06	0.10	0.10	0.10	0.10	0.10	-
128 Zinc*	15	146	0.65	113	0.10	0.10	0.10	-

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(1) BAT costs are incremental over BAT Feed costs.
*: Toxic pollutant found in all raw waste samples analyzed.

SUBCATEGORY SUMMARY DATA
BASIS 7/1/78 DOLLARS

Subcategory:	Hydrochloric Acid Pickling	Model Size-TPD :	2760
:	Continuous Type	Oper. Days/Year:	312
:	Carbon & Specialty	Turns/Day :	3

Raw Waste Flows	(MGD)
Model Plant:	1.35

No. of Plants: 40
Neutralization in Place: 31
Acid Regeneration in Place: 4
No Treatment (Acid Regeneration Required): 5
Total Flow for Subcategory: 57.1 MGD

Model Costs ($ x 10^{-3})	BAT Feed	BAT Alternatives 1	2	3
Neutralization System:				
Investment Cost	2590	293.0	470.0	2329.0
Annual Cost	805.7	91.1	124.3	577.0
$/Ton of Product(1)	0.94	0.11	0.14	0.67
Acid Regeneration System:				
Investment Cost	6846.0	339.0	562.0	2877.0
Annual Cost	-2195.2	105.4	147.8	748.4
$/Ton of Product(1)	-2.55	0.12	0.17	0.87

	Wastewater Parameter	Raw Waste Level					BAT Feed Level	BAT Effluent Level		
		Conc.	Rinse	FHS	AVS	Total		1	2	3
	Flow; neut. gal/ton	10	300	180	-	490	320	55	55	0
	Flow; Acid Regeneration, gal/ton	10	300	180	120	610	430	70	70	0
	pH, units	<1-5	1-5	<1-3.7	<1-7.6	<1-5 (<1-7.6)	6-9	6-9	6-9	-
	Concentrations (mg/l)									
	Suspended Solids	450	90	370	90	200 (180)	30	30	15	-
	Dissolved Iron	57,000	2700	820	650	3100 (2630)	1.0	1.0	1.0	-
	Oil & Grease	44	33	66	2	45 (37)	10	10	5	-
23	Chloroform	0.03	0.01	0.10	0.02	0.04 (0.04)	0.01	0.01	0.01	-
114	Antimony*	2.2	0.01	0.40	0.20	0.20 (0.20)	0.10	0.10	0.10	-
115	Arsenic*	0.20	0.09	0.05	0.02	0.10 (0.10)	0.10	0.10	0.10	-
118	Cadmium*	0.20	0.04	0.06	-	0.10 (0.10)	0.10	0.10	0.10	-
119	Chromium*	13	0.35	0.35	0.02	0.60 (0.50)	0.10	0.10	0.10	-
120	Copper*	13	0.60	0.80	0.80	1.0 (0.90)	0.10	0.10	0.10	-
122	Lead*	310	18	0.30	1.0	17.5 (14)	0.10	0.10	0.10	-
124	Nickel*	10	0.50	0.55	0.35	0.70 (0.65)	0.20	0.20	0.10	-
126	Silver*	0.20	0.06	0.10	0.10	0.10 (0.10)	0.10	0.10	0.10	-
128	Zinc*	15	146	0.65	1.0	90 (73)	0.10	0.10	0.10	-

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(1) BAT costs are incremental over BAT Feed costs.
*: Toxic pollutant found in all raw waste samples analyzed.

NOTE: Numbers in parenthesis represent values when the absorber vent scrubber wastes are included.

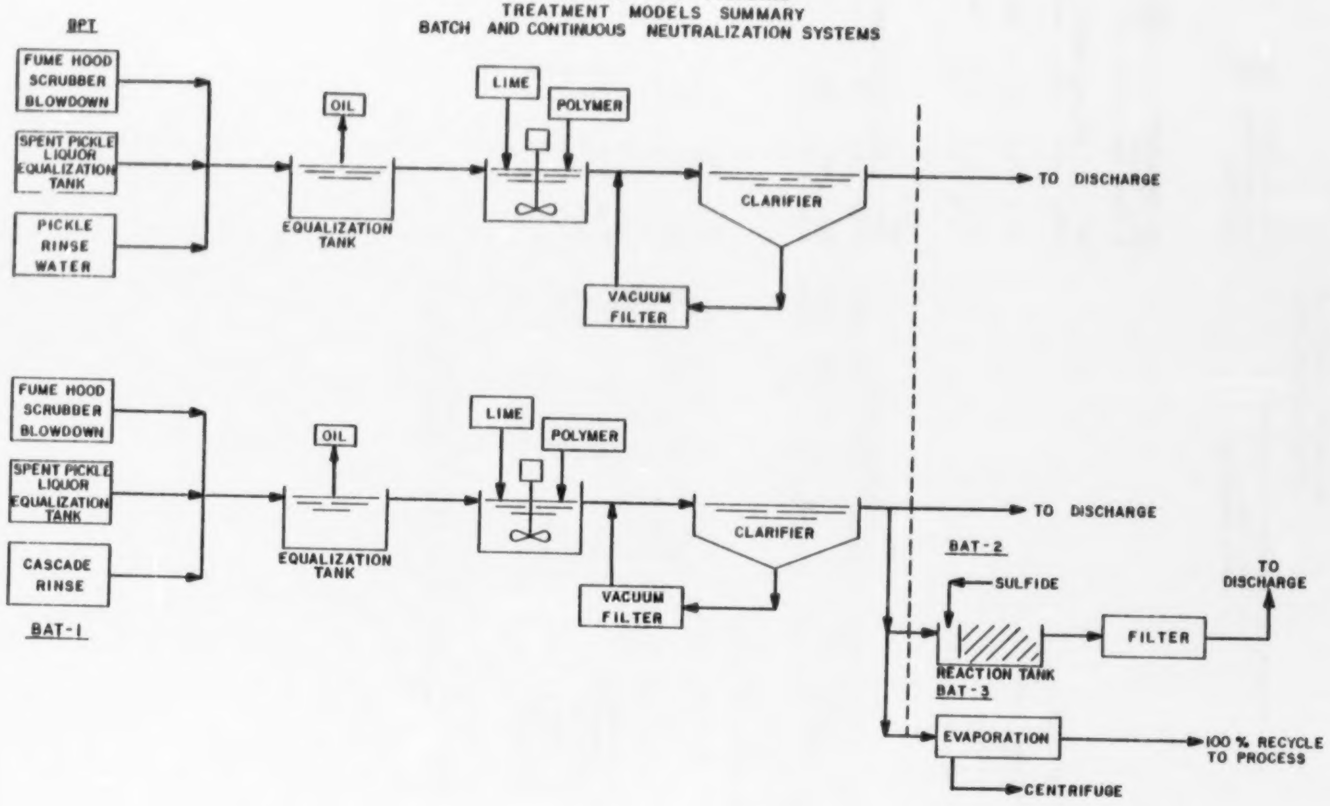
SUMMARY OF EFFLUENT LOADINGS (TONS/YEAR) AND TREATMENT COSTS
HYDROCHLORIC ACID PICKLING SUBCATEGORY

	Raw Waste Load	BAT Feed	BAT-1	BAT-2	BAT-3
Flow, MGD	58.0	38.8	6.5	6.5	0
TSS	14,613	1510	256	128	-
Oil and Grease	3,224	503	85.1	32.4	-
Dissolved Iron	224,067	50.3	8.5	8.5	-
Toxic Metals	7,916	50.3	8.5	7.6	-
Toxic Organics	3.0	0.5	0.08	0.08	-

OPTION COSTS
(MILLIONS OF DOLLARS)

Model Plant		BAT Feed	BAT-1	BAT 2	BAT 3
a. Continuous Operations (2760 TPD)					
Neutralization Systems:	Capital	2.60	0.29	0.47	2.33
	Annual	0.81	0.09	0.12	0.58
Acid Regeneration Systems:	Capital	6.85	0.34	0.56	2.88
	Annual	-2.20	0.11	0.15	0.75
b. Batch Operations (190 TPD)					
Neutralization System:	Capital	1.22	0.06	0.16	1.41
Only	Annual	0.25	0.02	0.04	0.27
Hydrochloric Acid Pickling Subcategory					
a. Continuous Neutralization:	Capital	80.60	8.99	14.57	72.23
31 Plants	Annual	25.11	2.79	3.72	17.98
b Continuous Acid Regeneration:	Capital	61.46	3.06	5.04	25.92
9 Plants	Annual	-19.80	0.99	1.35	6.75
c. Batch Neutralization:	Capital	8.54	0.42	1.12	9.87
7 Plants	Annual	1.75	0.14	0.28	1.89
d. Total for Subcategory:	Capital	150.79	12.47	20.73	108.02
47 Plants	Annual	7.06	3.92	5.35	26.62

COMBINATION ACID PICKLING TREATMENT MODELS SUMMARY BATCH AND CONTINUOUS NEUTRALIZATION SYSTEMS


BPT
FUME HOOD SCRUBBER BLOWDOWN
SPENT PICKLE LIQUOR EQUALIZATION TANK
PICKLE RINSE WATER
OIL
EQUALIZATION TANK
LIME
POLYMER
CLARIFIER
VACUUM FILTER
TO DISCHARGE
FUME HOOD SCRUBBER BLOWDOWN
SPENT PICKLE LIQUOR EQUALIZATION TANK
CASCADE RINSE
BAT-1
OIL
EQUALIZATION TANK
LIME
POLYMER
CLARIFIER
VACUUM FILTER
TO DISCHARGE
BAT-2
SULFIDE
REACTION TANK
BAT-3
FILTER
TO DISCHARGE
EVAPORATION
100 % RECYCLE TO PROCESS
CENTRIFUGE

SUBCATEGORY SUMMARY DATA
BASIS 7/1/78 DOLLARS

Subcategory: Combination Acid Pickling
: Batch Type
: Carbon-Specialty

Model Size-TPD : 200
Oper. Days/Year: 260
Turns/Day : 2

Raw Waste Flows	(MGD)
Model Plant:	0.34
50 Batch Type Plants:	16.75

Model Costs	BAT Feed	BAT Alternatives 1	2	3
Investment Cost $\$ \times 10^{-3}$	678.0	69.0	191.0	1559.0
Annual Cost $\$ \times 10^{-3}$	136.4	21.4	43.5	300.4
\$/Ton of Product(1)	2.62	0.41	0.84	5.78

Wastewater Parameters	Raw Waste Level Conc.	Rinse	FHS	Total	BAT Feed Level	BAT Effluent Levels 1	2	3
Flow, gal/ton	15	520	1140	1675	545	105	105	0
pH	<1-2.3	2-4	1.5-2-0	0.6-4	6-9	6-9	6-9	-
Concentrations (mg/l)								
Suspended Solids	130	50	25	34	30	30	15	-
Oil & Grease	0.40	4.6	0.30	1.6	2.0	2.0	2.0	-
Fluoride	3900	430	1800	1400	15	15	15	-
Dissolved Iron	19,000	230	50	275	1.0	1.0	1.0	-
115 Arsenic*	-	0.10	-	0.10	0.10	0.10	0.10	-
119 Chromium*	4300	48	2.4	55	0.10	0.10	0.10	-
120 Copper*	230	1.3	-	2.5	0.10	0.10	0.10	-
122 Lead*	27	0.07	-	0.10	0.10	0.10	0.10	-
124 Nickel*	5800	53	3.3	71	0.20	0.20	0.10	-
128 Zinc*	17	1.0	0.30	0.70	0.10	0.10	0.10	-

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(1) BAT costs are incremental over BAT Feed costs.
*: Toxic pollutant found in all waste samples analyzed.

SUBCATEGORY SUMMARY DATA
BASIS 7/1/78 DOLLARS

Subcategory:	Combination Acid Pickling	Model Size-TPD :	300
:	Continuous Type	Oper. Days/Year:	320
:	Carbon-Specialty	Turns/Day :	3

Raw Waste Flows	(MGD)
Model Plant:	1.27
19 Continuous Type Plants:	24.08

Model Costs	BAT Feed	BAT Alternatives 1	2	3
Investment Cost $\$ \times 10^{-3}$	1301	142.0	374.0	2653.0
Annual Cost $\$ \times 10^{-3}$	311.4	44.1	87.4	613.3
$/Ton of Product(1)	1.95	0.28	0.55	3.83

	Wastewater Parameters	Raw Waste Level Conc.	Rinse	FHS	Total	BAT Feed Level	BAT Effluent Levels 1	2	3
	Flow, gal/ton	15	1800	720	2535	1865	335	335	0
	pH	1.5	2.5-8	1.5- 2.0	1.5-8	6-9	6-9	6-9	-
	Concentrations (mg/l)								
	Suspended Solids	200	180	25	135	30	30	15	-
	Oil & Grease	3.5	3.3	0.30	2.4	2.0	2.0	2.0	-
	Fluoride	10,000	69	50	122	15	15	15	-
	Dissolved Iron	23,000	155	2.4	250	1.0	1.0	1.0	-
4	Benzene*	-	0.05	**	0.05	0.05	0.05	0.025	-
115	Arsenic	-	0.01	-	0.01	0.01	0.01	0.01	-
119	Chromium*	3300	25	8.3	40	0.10	0.10	0.10	-
120	Copper*	100	0.27	0.07	0.80	0.10	0.10	0.10	-
122	Lead	1.2	-	-	1.2	0.10	0.10	0.10	
124	Nickel*	3300	15	1800	540	0.20	0.20	0.10	-
128	Zinc*	4.1	0.40	0.30	0.40	0.10	0.10	0.10	-

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(1) BAT costs are incremental over BAT Feed costs.
* : Toxic pollutant found in all raw waste samples analyzed.
**: Value is less than 0.010 mg/l

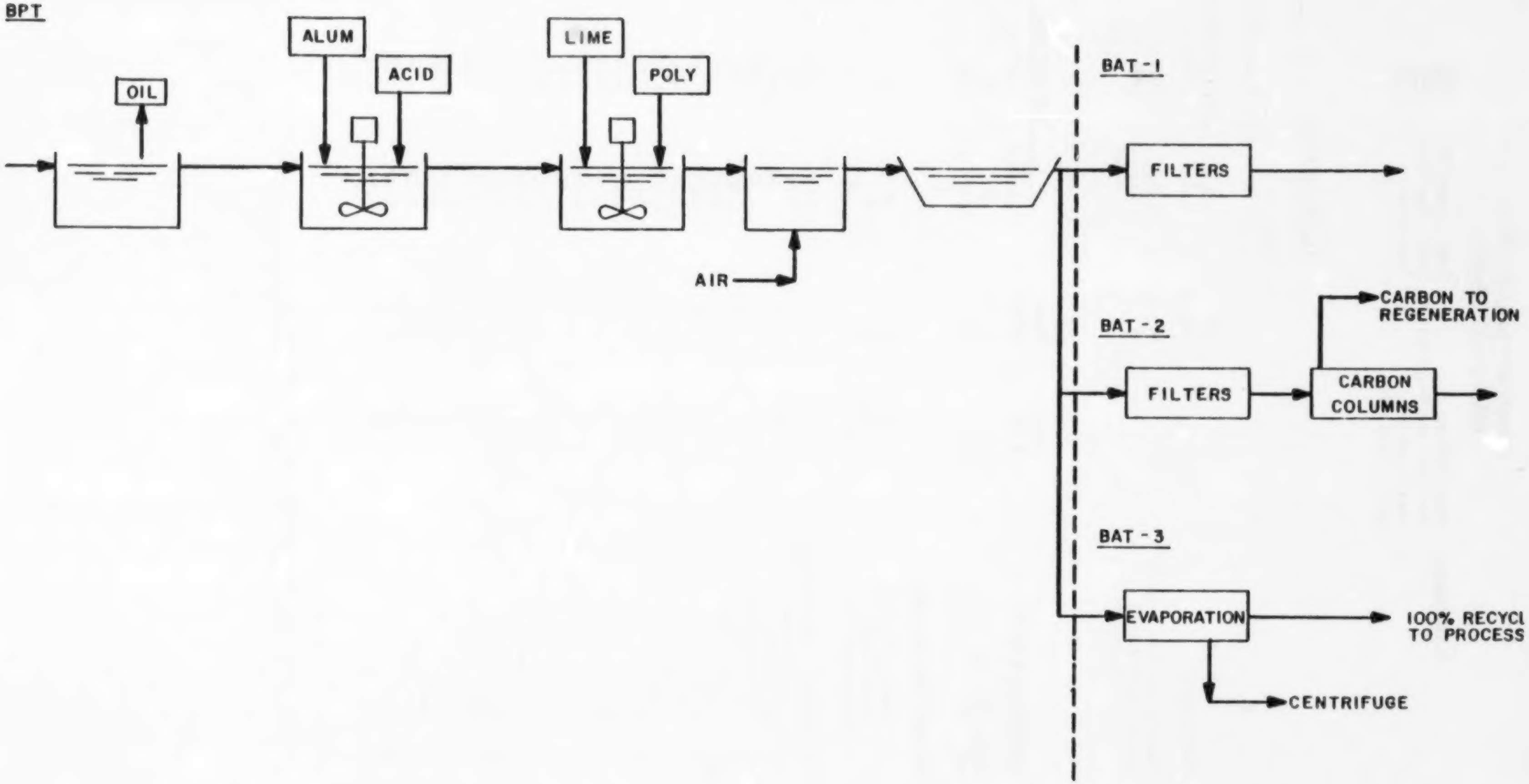
SUMMARY OF EFFLUENT LOADINGS (TONS/YEAR) AND TREATMENT COSTS
COMBINATION ACID PICKLING

	Raw Waste Load	BAT Feed	BAT-1	BAT-2	* BAT-3
Flow (MGD)	40.9	23.2	4.3	4.3	0
TSS	4955	886	161	80.7	-
Oil & Grease	106	59.1	10.8	10.8	-
Fluoride	29,345	444	80.8	80.8	-
Toxic Metals	21,066	18.5	3.4	2.9	-
Toxic Organics	1.6	1.2	0.2	0.1	-
Dissolved Iron	13,028	29.5	5.3	5.3	-

OPTION COSTS
(MILLIONS OF DOLLARS)

	BAT Feed	BAT-1	BAT-2	BAT-3
Model Plant				
a. Continuous Operations (500 TPD)				
Capital	1.30	0.14	0.37	2.65
Annual	0.31	0.04	0.09	0.61
b. Batch Operations (200 TPD)				
Capital	0.68	0.07	0.19	1.56
Annual	0.14	0.02	0.04	0.30
Combination Acid Pickling Subcategory				
a. Continuous (19 Plants)				
Capital	24.70	2.66	7.03	50.35
Annual	5.89	0.76	1.71	11.59
b. Batch (50 Plants)				
Capital	34.00	3.50	9.50	78.00
Annual	7.00	1.00	2.00	15.00
c. Total for Subcategory (69 plants)				
Capital	58.70	6.16	16.53	128.35
Annual	12.89	1.76	3.71	26.59

COLD ROLLING
TREATMENT MODELS SUMMARY


BPT
OIL
ALUM
ACID
LIME
POLY
AIR
BAT - 1
FILTERS
BAT - 2
FILTERS
CARBON COLUMNS
CARBON TO REGENERATION
BAT - 3
EVAPORATION
100% RECYC
TO PROCESS
CENTRIFUGE

SUBCATEGORY SUMMARY DATA
BASIS 7/1/78 DOLLARS

Subcategory: Cold Forming
: Cold Rolling Subdivision
: Recirculation
: Carbon-Specialty

Model Size-TPD : 1700
Oper. Days/Year: 348
Turns/Day : 3

Raw Waste Flows	(MGD)
Model Plant:	0.043
46 Recirculation Plant Sites:	1.96

Model Costs	BAT Feed	BAT Alternatives 1	2	3
Investment Cost \$ x 10^{-3}	509.0	132.0	1025.0	1389.0
Annual Cost \$ x 10^{-3}	97.1	24.0	1856.0	281.2
\$/Ton of Product (1)	-	0.041	3.14	0.48

	Wastewater Parameters	Raw Waste Level	BAT Feed Level	BAT Effluent Level 1	2	3
	Flow, gal/ton	25	25	25	25	0
	pH	6-9	6-9	6-9	6-9	-
	Concentrations (mg/l)					
	Suspended Solids	1,000	25	15	15	-
	Oil & Grease	20,000	10	5	5	-
	Dissolved Iron	100	1.0	1.0	1.0	-
6	Carbon Tetrachloride	0.02	0.02	0.02	0.02	-
11	1,1,1-Trichloroethane	0.10	0.10	0.10	0.10	-
23	Chloroform*	0.10	0.10	0.10	0.02	-
24	2-Chlorophenol	6.00	6.00	6.00	0.05	-
34	2,4-Dimethylphenol	4.20	4.20	4.20	0.05	-
38	Ethylbenzene	0.07	0.05	0.05	0.05	-
55	Naphthalene	0.09	0.05	0.05	0.025	-
57	2-Nitrophenol	12.00	12.00	12.00	0.05	-
60	4,6-Dinitro-o-cresol	0.20	0.20	0.025	0.025	-
65	Phenol*	0.02	0.02	0.02	0.02	-
78	Anthracene	3.00	0.01	0.01	0.01	-
80	Fluorene	0.03	0.01	0.10	0.01	-
85	Tetrachloroethylene*	0.30	0.30	0.05	0.05	-
86	Toluene	0.04	0.04	0.04	0.02	-
87	Trichloroethylene	0.03	0.03	0.03	0.03	-
114	Antimony*	0.03	0.03	0.03	0.03	-
115	Arsenic*	0.30	0.10	0.10	0.10	-
118	Cadmium	0.10	0.10	0.10	0.10	-
119	Chromium*	2.00	0.10	0.10	0.10	-
120	Copper*	4.20	0.10	0.10	0.10	-
122	Lead*	2.70	0.10	0.10	0.10	-
124	Nickel*	2.20	0.20	0.10	0.10	-
128	Zinc*	2.00	0.10	0.10	0.10	-
130	Xylene	1.50	1.50	1.50	0.05	-

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(1) BAT costs are incremental over BAT Feed costs.
* : Toxic pollutant found in all raw waste samples analyzed.

SUBCATEGORY SUMMARY DATA
BASIS 7/1/78 DOLLARS

Subcategory:	Cold Forming	Model Size-TPD :	4400
:	Cold Rolling Subdivision	Oper. Days/Year:	348
:	Combination	Turns/Day :	3
:	Carbon-Specialty		

Raw Waste Flows	(MGD)
Model Plant:	1.10
10 Combination Plant Sites:	11.00

Model Costs	BAT Feed	BAT Alternatives 1	2	3
Investment Cost $ x 10^{-3}	1289.0	539.0	3457.0	10450.0
Annual Cost $ x 10^{-3}	361.3	104.1	1379.8	2727.8
$/Ton of Product$^{(1)}$	-	0.068	0.90	1.78

	Wastewater Parameters	Raw Waste Level	BAT Feed Level	BAT Effluent Level 1	2	3
	Flow, gal/ton	250	250	250	250	0
	pH	6-9	6-9	6-9	6-9	-
	Concentrations (mg/l)					
	Suspended Solids	600	25	15	15	-
	Oil & Grease	1000	10	5	5	-
	Dissolved Iron	10	1.0	1.0	1.0	-
6	Carbon Tetrachloride	0.02	0.02	0.02	0.02	-
11	1,1,1-Trichloroethane	0.10	0.10	0.10	0.10	-
23	Chloroform	0.15	0.10	0.10	0.02	-
24	2-Chlorophenol	3.00	3.00	3.00	0.05	-
34	2-4-Dimethylphenol	2.00	2.00	2.00	0.05	-
38	Ethylbenzene	0.03	0.03	0.03	0.03	-
55	Naphthalene	0.02	0.02	0.02	0.02	-
57	2-Nitrophenol	6.00	6.00	6.00	0.05	-
60	4,6-Dinitro-o-cresol	0.10	0.10	0.025	0.025	-
65	Phenol	0.10	0.10	0.10	0.05	-
78	Anthracene	0.20	0.01	0.01	0.01	-
80	Fluorene	0.01	0.01	0.01	0.01	-
85	Tetrachloroethylene	0.15	0.15	0.05	0.05	-
86	Toluene	0.02	0.02	0.02	0.02	-
87	Trichloroethylene	0.02	0.02	0.02	0.02	-
114	Antimony	0.02	0.02	0.02	0.02	-
115	Arsenic	0.10	0.10	0.10	0.10	-
118	Cadmium	0.08	0.08	0.08	0.08	-
119	Chromium	1.00	0.10	0.10	0.10	-
120	Copper	2.00	0.10	0.10	0.10	-
122	Lead	1.50	0.10	0.10	0.10	-
124	Nickel	0.90	0.20	0.10	0.10	-
128	Zinc	0.90	0.10	0.10	0.10	-
130	Xylene	0.35	0.35	0.35	0.05	-

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(1) BAT costs are incremental over BAT Feed costs.

SUBCATEGORY SUMMARY DATA
BASIS 7/1/78 DOLLARS

Subcategory:	Cold Forming	Model Size-TPD :	2900
:	Cold Rolling Subdivision	Oper. Days/Year:	348
:	Direct Application	Turns/Day :	3
:	Carbon-Specialty		

Raw Waste Flows	(MGD)
Model Plant:	1.16
23 DA Plant Sites:	26.68

Model Costs	BAT Feed	BAT Alternatives 1	2	3
Investment Cost $ x 10^{-3}	1322.0	540.0	3551.0	10450.0
Annual Cost $ x 10^{-3}	383.0	104.2	1419.1	2775.0
$/Ton of Product (1)	-	0.10	1.41	2.75

WASTEWATER PARAMETERS	Raw Waste Level	BAT Feed Level	BAT Effluent Level 1	2	3
Flow, gal/ton	400	400	400	400	0
pH	6-9	6-9	6-9	6-9	-
CONCENTRATIONS (mg/1)					
Suspended Solids	100	25	15	15	-
Oil & Grease	1025	10	5	5	-
Dissolved Iron	25	1.0	1.0	1.0	-
4 Benzene	0.01	0.01	0.01	0.01	-
6 Carbon Tetrachloride	0.01	0.01	0.01	0.01	-
11 1,1,1-Trichloroethane*	0.05	0.05	0.05	0.05	-
78 Anthracene	0.03	0.03	0.03	0.03	-
85 Tetrachloroethylene	0.03	0.03	0.03	0.03	-
115 Arsenic*	0.02	0.02	0.02	0.02	-
117 Beryllium	0.01	0.01	0.01	0.01	-
119 Chromium*	0.10	0.10	0.10	0.10	-
120 Copper*	0.16	0.10	0.10	0.10	-
122 Lead*	0.40	0.10	0.10	0.10	-
124 Nickel*	0.30	0.20	0.10	0.10	-
128 Zinc*	0.15	0.10	0.10	0.10	-

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(1) BAT costs are incremental over BAT Feed costs.
*: Toxic pollutant found in all raw waste samples analyzed.

SUMMARY OF EFFLUENT LOADINGS (TONS/YEAR) AND TREATMENT COSTS
COLD ROLLING SUBDIVISION - RECIRCULATION

	Raw Waste Load	BAT Feed	BAT-1	BAT-2	BAT-3
Flow (MGD)	1.96	1.96	1.96	1.96	0
TSS	2,844.27	71.11	42.66	42.66	0
Oil & Grease	56,885.47	28.44	14.22	14.22	0
Toxic Metals	38.48	2.36	2.08	2.08	0
Toxic Organics	78.79	70.05	68.86	1.51	0

OPTIONS COSTS
(MILLIONS OF DOLLARS)

	BAT Feed	BAT-1	BAT-2	BAT-3
Model Plant (1700 TPD)				
Capital	0.51	0.13	1.025	1.39
Annual	0.097	0.024	1.85	0.28
Subdivision (46 Plants)				
Capital	23.41	6.07	47.15	63.89
Annual	4.46	1.10	85.38	12.94

SUMMARY OF EFFLUENT LOADINGS (TONS/YEAR) AND TREATMENT COSTS
COLD ROLLING SUBDIVISION - COMBINATION

	Raw Waste Load	BAT Feed	BAT-1	BAT-2	BAT-3
Flow (MGD)	11.00	11.00	11.00	11.00	0
TSS	9,577.66	399.07	239.44	239.44	0
Oil & Grease	15,962.76	159.62	79.81	79.81	0
Toxic Metals	103.76	12.03	11.17	11.17	0
Toxic Organics	195.86	192.03	189.32	8.30	0

OPTION COSTS
(MILLIONS OF DOLLARS)

	BAT Feed	BAT-1	BAT-2	BAT-3
Model Plant (4400 TPD)				
Capital	1.29	0.54	3.46	10.45
Annual	0.36	0.10	1.38	2.73
Subdivision (10 Plants)				
Capital	12.89	5.39	34.57	104.50
Annual	3.61	1.04	13.79	27.28

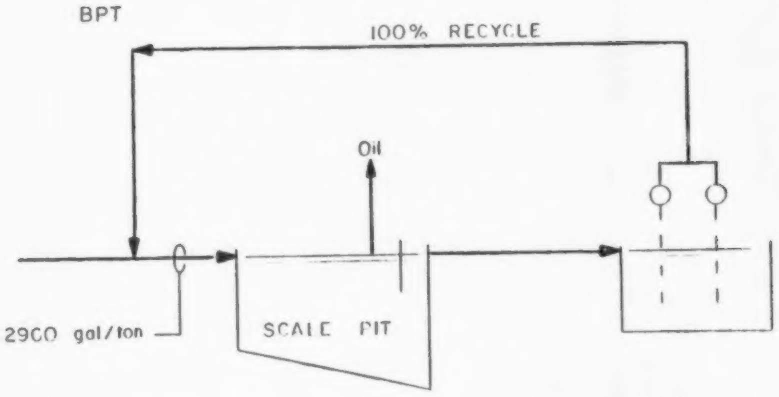
SUMMARY OF EFFLUENT LOADINGS (TONS/YEAR) AND TREATMENT COSTS
COLD ROLLING SUBDIVISION - DIRECT APPLICATION

	Raw Waste Load	BAT Feed	BAT-1	BAT-2	BAT-3
Flow (MGD)	26.68	26.68	26.68	26.68	0
TSS	3,871.69	967.92	580.75	580.75	0
Oil & Grease	39,684.87	387.17	193.58	193.58	0
Toxic Metals	44.14	24.39	20.52	20.52	0
Toxic Organics	5.03	5.03	5.03	5.03	0

OPTION COSTS
(MILLIONS OF DOLLARS)

	BAT Feed	BAT-1	BAT-2	BAT-3
Model Plant (2900 TPD)				
Capital	1.32	0.54	3.55	10.45
Annual	0.38	0.10	1.42	2.78
Subdivision (23 Plants)				
Capital	30.41	12.48	81.67	240.35
Annual	8.81	2.40	32.64	63.83

COLD FORMING
PIPE AND TUBE (WATER)
TREATMENT MODEL SUMMARY


BPT
100% RECYCLE
Oil
2900 gal/ton
SCALE PIT

SUBCATEGORY SUMMARY TABLE
BASIS 7/1/78 DOLLARS

Subcategory:	Cold Forming	Model Size-TPD :	500
:	Cold Working Pipe & Tube	Oper. Days/Year:	260
:	Using Water	Turns/Day :	3

Raw Waste Flows	(MGD)
Model Plant:	1.48
20 Plants :	29.60

Model Costs	BAT Feed	BAT
Investment Cost $ x 10^{-3}	498	0
Annual Cost $ x 10^{-3}	90.2	0
$/Ton of Product	0.694	0

Wastewater Pollutants	Raw Waste Level	Effluent Quality	
Flow (gal/ton)	2960	0	0
pH, Units	6-9	-	-
Concentrations (mg/1)			
Suspended Solids	25	-	-
Oil & Grease	65	-	-

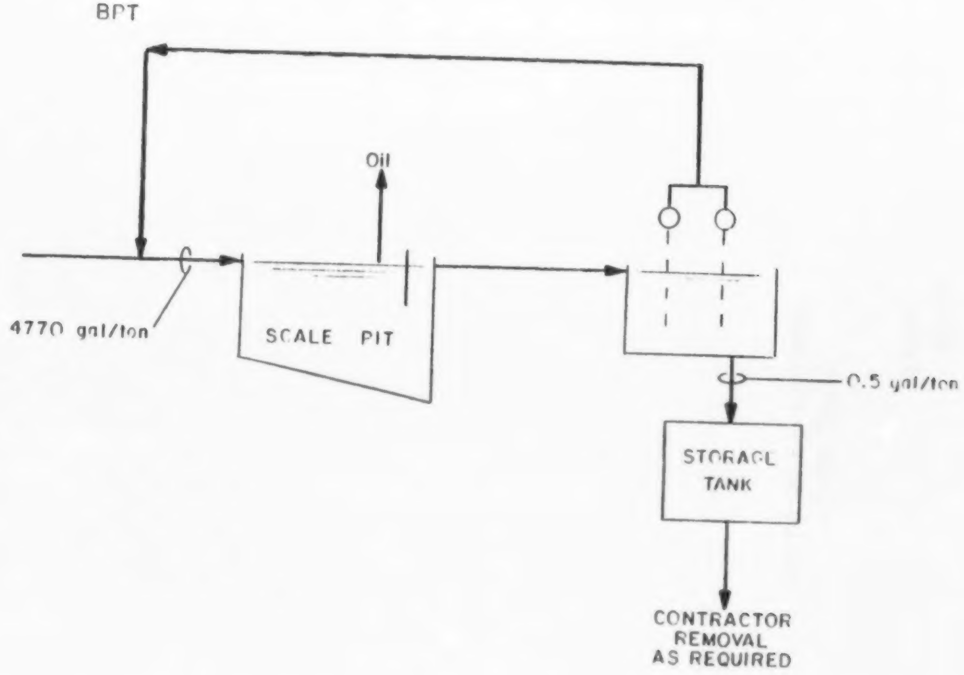
SUMMARY OF EFFLUENT LOADINGS (TONS/YEAR) AND TREATMENT COSTS
COLD FORMING: PIPE AND TUBE (WATER)

	Raw Waste Load	BPT
Flow (MGD)	29.60	Zero Discharge
TSS	802.3	
Oil and Grease	2,086	

OPTION COSTS
(MILLIONS OF DOLLARS)

Model Plant (500 tons/day)	BPT
Investment	0.50
Annual	0.09
Subcategory (20 plants)	
Investment	9.96
Annual	1.80

COLD FORMING
PIPE AND TUBE (SOLUBLE OIL)
TREATMENT MODEL SUMMARY


BPT
Oil
4770 gal/ton
SCALE PIT
0.5 gal/ton
STORAGE TANK
CONTRACTOR REMOVAL AS REQUIRED

SUBCATEGORY SUMMARY TABLE
BASIS 7/1/78 DOLLARS

Subcategory:	Cold Forming	Model Size-TPD :	270
:	Cold Working Pipe & Tube	Oper. Days/Year:	260
:	Using Soluble Oil Solutions	Turns/Day :	3

Raw Waste Flows	(MGD)
Model Plant:	1.29
14 Plants :	18.03

Model Costs	BAT Feed	BAT
Investment Cost \$ x 10^{-3}	424	0
Annual Cost \$ x 10^{-3}	78.4	0
\$/Ton of Product	1.117	0

Wastewater Pollutants	Raw Waste Level	Effluent Quality	
Flow (gal/ton)	4770	0	0
pH, Units	6-9	-	-
Concentrations (mg/l)			
Suspended Solids	1000	-	-
Oil & Grease	100,000	-	-

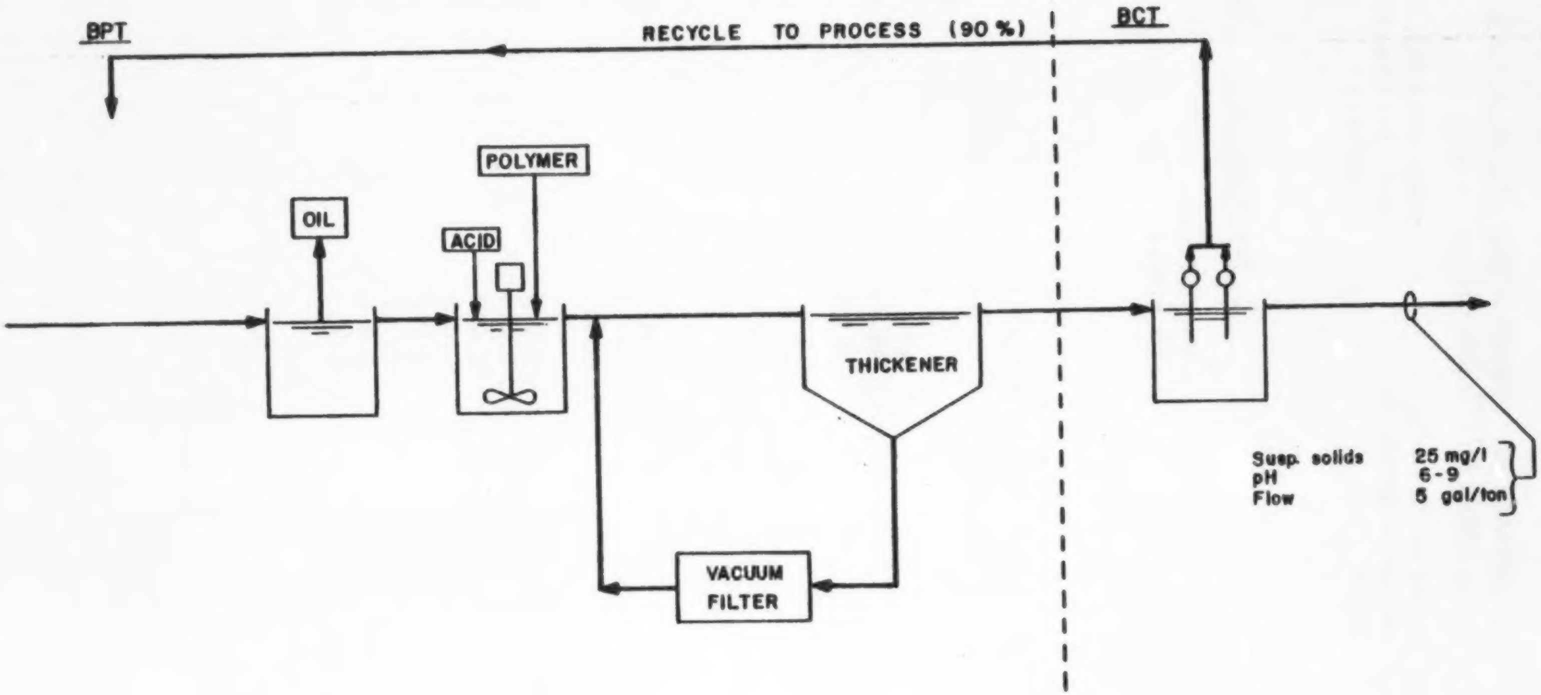
SUMMARY OF EFFLUENT LOADINGS (TONS/YEAR) AND TREATMENT COSTS
COLD FORMING: PIPE AND TUBE (OIL SOLUTIONS)

	Raw Waste Load	BPT
Flow (MGD)	18.03	Zero Discharge
TSS	19,549	
Oil and Grease	1,955,000	

OPTION COSTS
(MILLIONS OF DOLLARS)

Model Plant (270 tons/day)	BPT
Investment	0.42
Annual	0.08
Subcategory (14 plants)	
Investment	5.94
Annual	1.10

ALKALINE CLEANING
TREATMENT MODELS SUMMARY


BPT
RECYCLE TO PROCESS (90 %)
BCT
OIL
ACID
POLYMER
THICKENER
VACUUM FILTER
Susp. solids 25 mg/l
pH 6-9
Flow 5 gal/ton

SUBCATEGORY SUMMARY DATA
BASIS 7/1/78 DOLLARS

Subcategory:	Alkaline Cleaning	Model Size-TPD :	150
:	Carbon & Specialty	Oper. Days/Year:	250
:	Batch	Turns/Day: :	2

Raw Waste Flows	(MGD)
Model Plant:	0.0075
29 Plants:	0.22

Model Costs	BPT
Investment Cost $ x 10^{-3}	211
Annual Cost $ x 10^{-3}	38.2
$/Ton of Product	1.02

	Wastewater Pollutants	Raw Waste Level	BPT Effluent Level
	Flow, gal/ton	50	50
	pH, Units	9-12	6-9
	Concentrations (mg/l)		
	Suspended Solids	500	25
	Oil and Grease	20	10
	Dissolved Iron	0.50	0.50
36	2,6-Dinitrotoluene	0.020	0.020
39	Fluoranthene	0.015	0.015
84	Pyrene	0.010	0.010
114	Antimony	0.015	0.015
121	Cyanide	0.010	0.010
122	Lead	0.020	0.020
125	Selenium	0.015	0.015
128	Zinc	0.20	0.20

SUBCATEGORY SUMMARY DATA
BASIS 7/1/78 DOLLARS

Subcategory:	Alkaline Cleaning	Model Size-TPD :	1500
:	Carbon & Specialty	Oper. Days/Year:	250
:	Continuous	Turns/Day :	2

Raw Waste Flows (MGD)	
Model Plant:	0.075
36 Plants:	2.70

Model Costs	BPT
Investment Cost $ x 10^{-3}	456
Annual Cost $ x 10^{-3}	84.4
$/Ton of Product	0.23

	Wastewater Pollutants	Raw Level	BPT Effluent Level
	Flow, gal/ton	50	50
	pH, Units	9-12	6-9
	Concentration (mg/l)		
	Suspended Solids	500	25
	Oil and Grease	20	10
	Dissolved Iron	0.50	0.50
36	2,6-Dinitrotoluene	0.020	0.020
39	Fluoranthene	0.015	0.015
84	Pyrene	0.010	0.010
114	Antimony	0.015	0.015
121	Cyanide	0.010	0.010
122	Lead	0.020	0.020
125	Selenium	0.015	0.015
128	Zinc	0.20	0.20

SUMMARY OF EFFLUENT LOADINGS (TONS/YEAR) AND TREATMENT COSTS ALKALINE CLEANING SUBCATEGORY

	Raw Waste Load	BPT Load
Flow (MGD)	2.92	2.92
TSS	1520.75	76.04
Oil & Grease	60.83	30.41
Dissolved Iron	1.52	1.52
Toxic Metals	0.76	0.76
Toxic Organics	0.17	0.17

OPTION COSTS (MILLIONS OF DOLLARS)

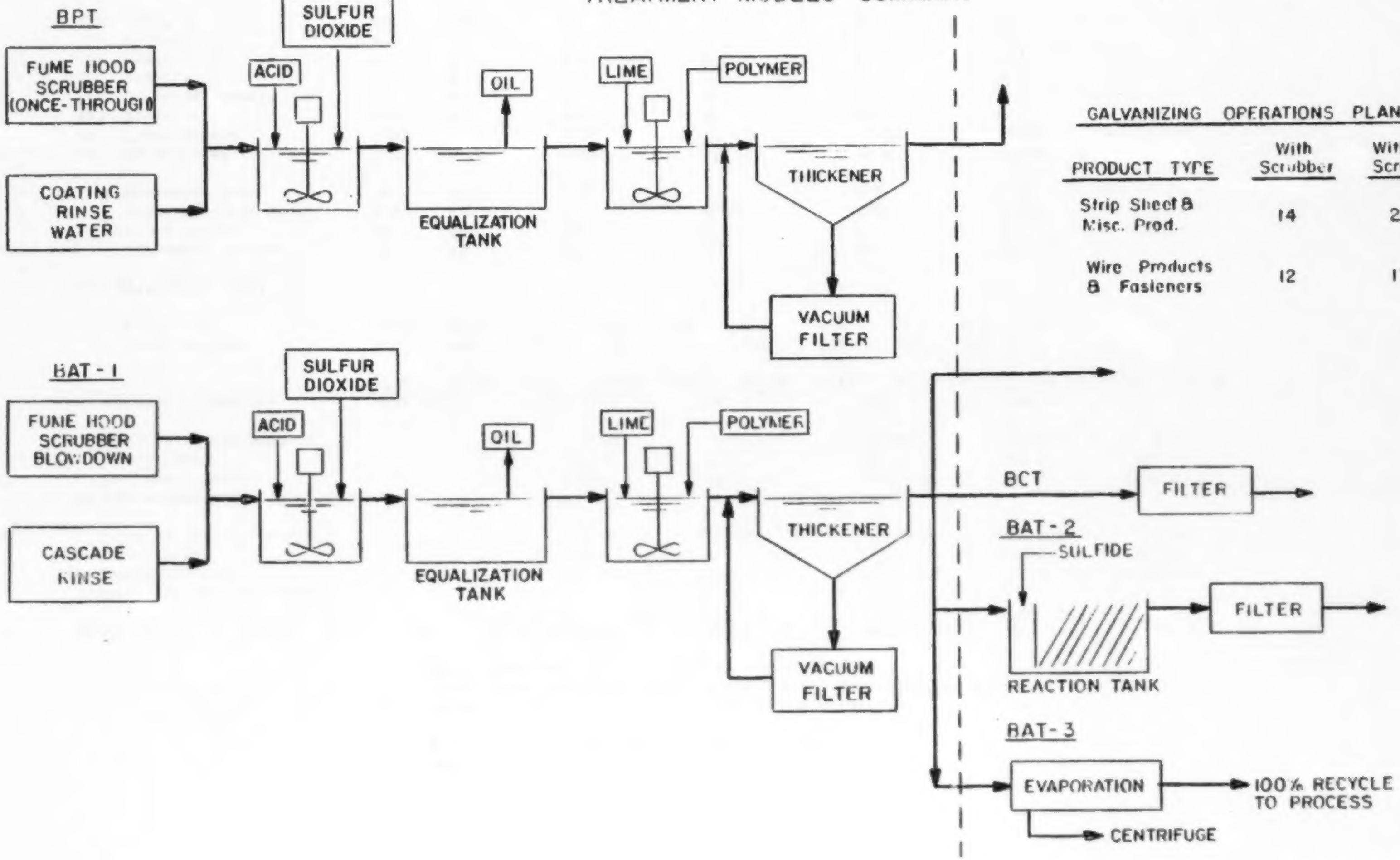
BATCH

Model Plant (150 TPD)	BPT
Capital	0.21
Annual	0.038
Subcategory (29 Plants)	
Capital	6.09
Annual	1.10

CONTINUOUS

Model Plant (1500 TPD)	
Capital	0.46
Annual	0.084
Subcategory (36 Plants)	
Capital	16.56
Annual	3.02

HOT COATING - GALVANIZING OPERATIONS
TREATMENT MODELS SUMMARY


BPT
FUME HOOD SCRUBBER (ONCE-THROUGH)
COATING RINSE WATER
ACID
SULFUR DIOXIDE
OIL
EQUALIZATION TANK
LIME
POLYMER
THICKENER
VACUUM FILTER
BAT - 1
FUME HOOD SCRUBBER BLOWDOWN
CASCADE RINSE
ACID
SULFUR DIOXIDE
OIL
EQUALIZATION TANK
LIME
POLYMER
THICKENER
VACUUM FILTER
BCT
FILTER
BAT - 2
SULFIDE
REACTION TANK
FILTER
BAT - 3
EVAPORATION
100% RECYCLE TO PROCESS
CENTRIFUGE

GALVANIZING OPERATIONS PLANTS

PRODUCT TYPE	With Scrubber	Without Scrubbers
Strip Sheet & Misc. Prod.	14	20
Wire Products & Fasteners	12	17

SUBCATEGORY SUMMARY: BASIS 7/1/78 DOLLARS

Subcategory: Hot Coating-Galvanizing
: Continuous and Batch
: Strip,Sheet, & Misc. Products

Model Size-TPD : 800
Oper. Days/Year: 260
Turns/Day : 3

Raw Waste Flows	(MGD)
Model Plant - no fume scrubbers:	0.48
Model Plant - with fume scrubbers:	0.96

Number of plants: 34 total, 14 with fume scrubbers
Total flow for strip, sheet, & misc. prod. galvanizing: 23.0 MGD
Total flow assuming scrubbers required: 32.6 MGD

Model Costs ($ x 10^{-3})	BAT Feed	BAT 1	BCT	BAT 2	BAT 3
Plants with fume scrubbers					
Investment Cost	1235.0	265.0	400.0	428.0	2749.0
Annual Cost	258.3	71.9	96.4	102.2	607.7
$/ton of coated product(1)	1.24	0.346	0.463	0.491	2.92
Plants without fume scrubbers					
Investment Costs	892.0	188.0	305.0	333.0	2501.0
Annual Cost	182.3	58.2	79.4	85.0	539.7
$/ton of coated product(1)	0.876	0.280	0.382	0.409	2.59

Wastewater Parameters	Raw Waste		BAT Feed		BAT 1		BCT		BAT 2		BAT 3	
	w/fs	no fs	w/fs	no fs	w/fs	no fs	w/fs	no fs	w/fs	no fs	w/fs	no fs
Flow, gal/ton	1200	600	1200	600	200	150	200	150	200	150	0	0
pH (Units)	2-10	2-9	6-9	6-9	6-9	6-9	6-9	6-9	6-9	6-9	-	-
Concentrations, mg/l												
Suspended Solids	50	75	50		30		15		15		-	-
Oil & Grease	40	60	15		5		5		5		-	-
Hexavalent Chromium	1.0	2.0	0.02		0.02		0.02		0.02		-	-
Dissolved Iron	50	75	1.0		0.2		0.2		0.2		-	-
23 Chloroform*	0.03	0.04	0.02		<0.01		<0.01		<0.01		-	-
39 Fluoranthene	0.02	0.03	0.01		<0.01		<0.01		<0.01		-	-
115 Arsenic*	0.1	0.2	0.1		0.1		0.1		0.1		-	-
119 Chromium, Total*	5	10	3		0.1		0.1		0.1		-	-
120 Copper*	1.0	2	0.5		0.1		0.1		0.1		-	-
122 Lead*	5	8	1.0		0.1		0.1		0.1		-	-
124 Nickel*	0.6	1.0	0.5		0.2		0.1		0.1		-	-
128 Zinc*	80	150	5		0.1		0.1		0.1		-	-

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(1) BAT and BCT costs are incremental over BAT Feed costs.
*: Toxic pollutant found in all raw waste samples analyzed.

SUBCATEGORY SUMMARY: BASIS 7/1/78 DOLLARS

Subcategory: Hot Coating-Galvanizing
: Continuous and Batch
: Wire,Wire Products & Fasteners

Model Size-TPD : 100
Oper. Days/Year: 260
Turns/Day : 3

Raw Waste Flows	(MGD)
Model Plant - no fume scrubbers:	0.24
Model Plant - with fume scrubbers:	0.39

Number of plants: 29 total, 12 with fume scrubbers
Total flow for wire, wire prod. & fasteners galvanizing: 8.76 MGD
Total flow assuming scrubbers required: 11.31 MGD

Model Costs ($ x 10^{-3})	BAT Feed	BAT 1	BCT	BAT 2	BAT 3
Plants with fume scrubbers					
Investment Cost	812.0	108.0	212.0	237.0	2164.0
Annual Cost	161.8	26.3	45.1	50.0	435.9
$/ton of coated product(1)	6.22	1.01	1.73	1.92	16.77
Plants without fume scrubbers					
Investment Costs	621.0	54.0	151.0	174.0	2000.0
Annual Cost	121.4	16.7	34.2	38.7	398.5
$/ton of coated product(1)	4.67	0.642	1.32	1.49	15.33

Wastewater Parameters	Raw Waste		BAT Feed		BAT 1		BCT		BAT 2		BAT 3	
	w/fs	no fs	w/fs	no fs	w/fs	no fs	w/fs	no fs	w/fs	no fs	w/fs	no fs
Flow, gal/ton	3900	2400	3900	2400	750	600	750	600	750	600	0	0
pH (Units)	3-9	3-9	6-9	6-9	6-9	6-9	6-9	6-9	6-9	6-9	-	-
Concentrations, mg/l												
Suspended Solids	100	150	50		30		15		15		-	-
Oil & Grease	25	40	15		5		5		5		-	-
Hexavalent Chromium	0.5	1.0	0.02		0.02		0.02		0.02		-	-
Dissolved Iron	40	75	1.0		0.2		0.2		0.2		-	-
11 1,1,1-Trichloroethane	0.03	0.04	0.02		<0.01		<0.01		<0.01		-	-
23 Chloroform*	0.01	0.02	0.01		<0.01		<0.01		<0.01		-	-
87 Trichloroethylene	0.02	0.03	0.01		<0.01		<0.01		<0.01		-	-
115 Arsenic*	0.1	0.2	0.1		0.1		0.1		0.1		-	-
119 Chromium, Total*	1.0	2.5	1.0		0.1		0.1		0.1		-	-
120 Copper*	0.4	0.8	0.4		0.1		0.1		0.1		-	-
122 Lead*	1.0	2.0	1.0		0.1		0.1		0.1		-	-
124 Nickel*	0.2	0.5	0.2		0.2		0.1		0.1		-	-
128 Zinc*	20	35	5.0		0.1		0.1		0.1		-	-

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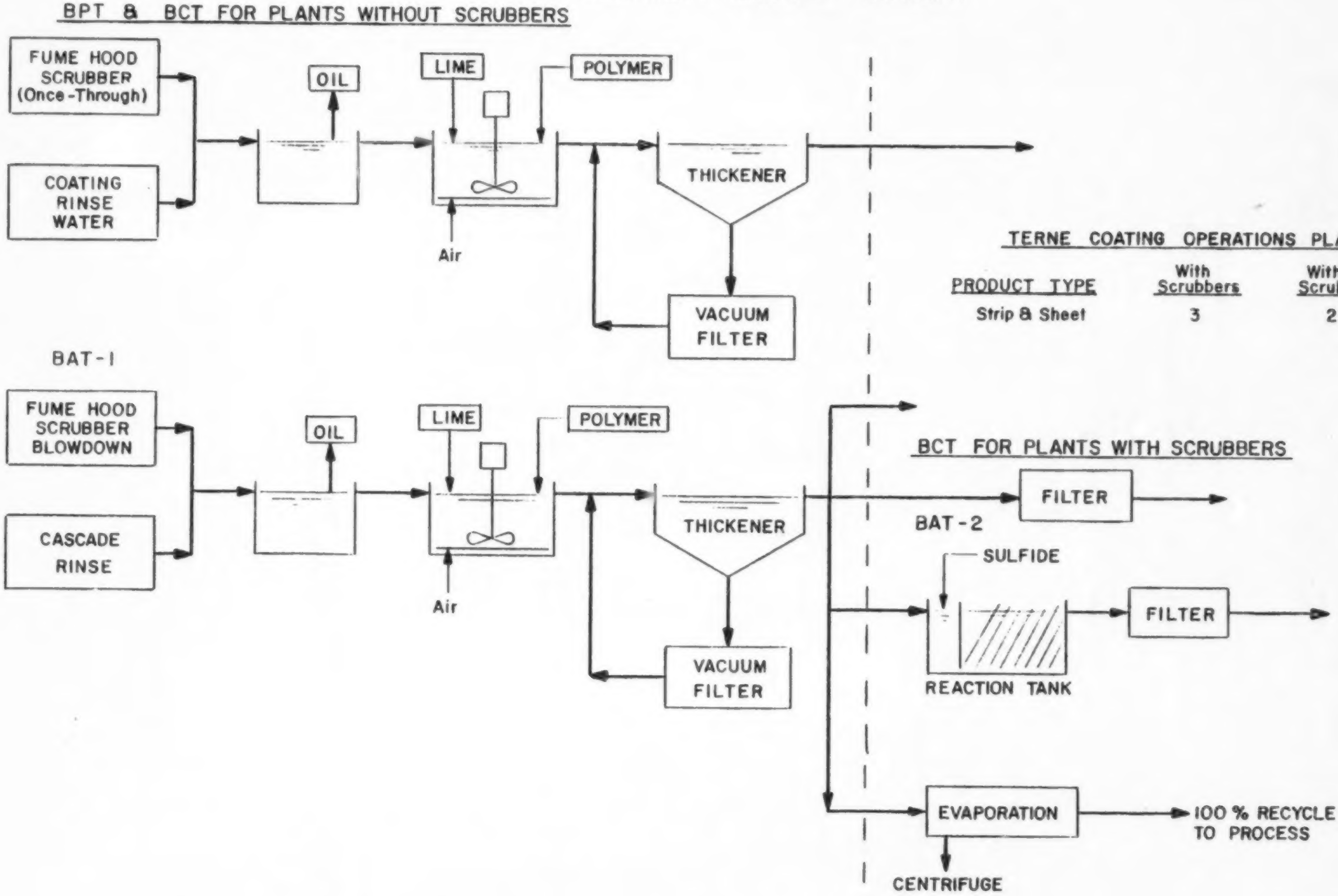
(1) BAT and BCT costs are incremental over BAT Feed costs.
*: Toxic pollutant found in all raw waste samples analyzed.

HOT COATING - TERNE COATING TREATMENT MODELS SUMMARY


BPT & BCT FOR PLANTS WITHOUT SCRUBBERS
FUME HOOD SCRUBBER (Once-Through)
COATING RINSE WATER
OIL
LIME
POLYMER
Air
THICKENER
VACUUM FILTER
BAT-1
FUME HOOD SCRUBBER BLOWDOWN
CASCADE RINSE
OIL
LIME
POLYMER
Air
THICKENER
VACUUM FILTER
BCT FOR PLANTS WITH SCRUBBERS
FILTER
BAT-2
SULFIDE
REACTION TANK
FILTER
EVAPORATION
100 % RECYCLE TO PROCESS
CENTRIFUGE

TERNE COATING OPERATIONS PLANTS

PRODUCT TYPE	With Scrubbers	Without Scrubbers
Strip & Sheet	3	2

SUBCATEGORY SUMMARY: BASIS 7/1/78 DOLLARS

Subcategory:	Hot Coating-Terne	Model Size-TPD :	365
:	Continuous Only	Oper. Days/Year:	260
:	Strip,Sheet Only	Turns/Day :	3

Raw Waste Flows	(MGD)
Model Plant - no fume scrubbers:	0.219
Model Plant - with fume scrubbers:	0.438

Number of plants: 5 total, 3 with fume scrubbers
Total flow for terne coating: 1.75 MGD
Total flow assuming scrubbers required: 2.19 MGD

odel Costs ($ x 10^{-3})	BAT Feed	BAT 1	BCT	BAT 2	BAT 3
lants with fume scrubbers					
Investment Cost	838.0	187.0	291.0	316.0	2232.0
Annual Cost	163.0	48.7	67.5	72.4	455.6
$/ton of coated product(1)	1.72	0.513	0.711	0.763	4.80
lants without fume scrubbers					
Investment Costs	612.0	117.0	0	226.0	2017.0
Annual Cost	117.7	36.3	0	56.2	406.5
$/ton of coated product(1)	1.24	0.383	0	0.592	4.28

	astewater Parameters	Raw Waste		BAT Feed		BAT 1		BCT		BAT 2		BAT 3	
		w/fs	no fs	w/fs	no fs	w/fs	no fs	w/fs	no fs	w/fs	no fs	w/fs	no
	Flow, gal/ton	1200	600	1200	600	200	150	200	600	200	150	0	0
	pH (Units)	3-9	3-9	6-9	6-9	6-9	6-9	6-9	6-9	6-9	6-9	-	-
	oncentrations, mg/l												
	Suspended Solids	50	75	50		30		15	50	15		-	-
	Oil & Grease	25	40	15		5		5	15	5		-	-
	Hexavalent Chromium	0.02	0.04	0.02		0.02		0.02	0.02	0.02		-	-
	Dissolved Iron	50	75	1.0		0.2		0.2	1.0	0.20		-	-
	Tin	5	10	5		3.0		0.1	5	0.10		-	-
3	Chloroform*	0.05	0.08	0.02		0.02		<0.01	0.02	<0.01		-	-
5	Tetrachloroethylene*	0.01	0.02	<0.01		<0.01		<0.01	<0.01	<0.01		-	-
15	Arsenic*	0.1	0.1	0.1		0.1		0.1	0.1	0.1		-	-
18	Cadmium*	0.1	0.1	0.1		0.1		0.1	0.1	0.1		-	-
19	Chromium, Total*	3.0	5.0	2.0		0.1		0.1	2.0	0.1		-	-
20	Copper*	0.5	1.0	0.3		0.1		0.1	0.3	0.1		-	-
22	Lead*	0.5	1.0	0.5		0.1		0.1	0.5	0.1		-	-
24	Nickel*	0.8	2.0	0.4		0.2		0.1	0.4	0.1		-	-
28	Zinc*	1.0	2.0	0.5		0.1		0.1	0.5	0.1		-	-

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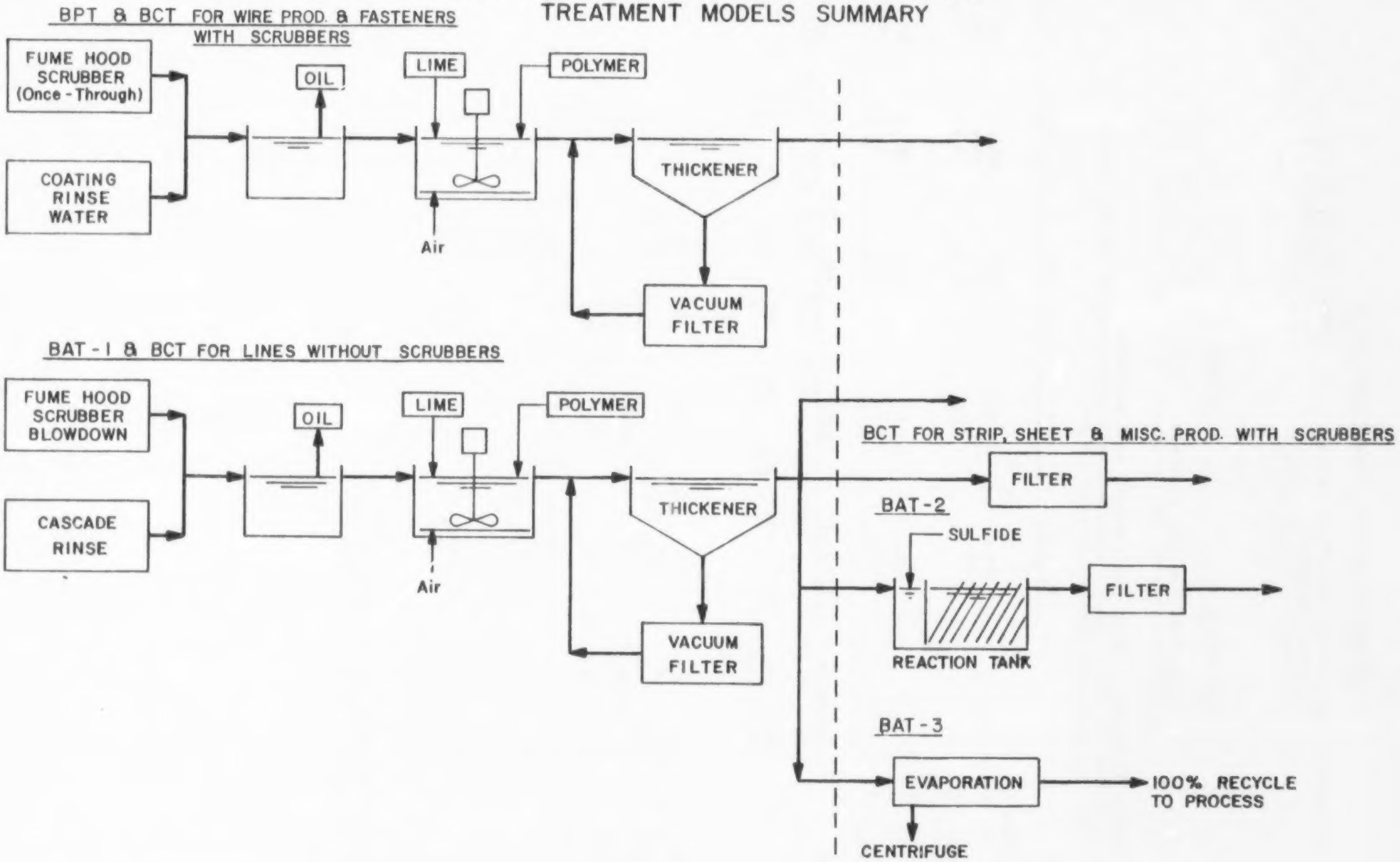
1) BAT and BCT costs are incremental over BAT Feed costs.
Total pollutant found in all raw waste samples analyzed.

HOT COATING - OTHER METALLIC COATINGS TREATMENT MODELS SUMMARY


BPT & BCT FOR WIRE PROD. & FASTENERS WITH SCRUBBERS
FUME HOOD SCRUBBER (Once - Through)
COATING RINSE WATER
OIL
LIME
POLYMER
Air
THICKENER
VACUUM FILTER
BAT - 1 & BCT FOR LINES WITHOUT SCRUBBERS
FUME HOOD SCRUBBER BLOWDOWN
CASCADE RINSE
OIL
LIME
POLYMER
Air
THICKENER
VACUUM FILTER
BCT FOR STRIP, SHEET & MISC. PROD. WITH SCRUBBERS
FILTER
BAT-2
SULFIDE
REACTION TANK
FILTER
BAT-3
EVAPORATION
CENTRIFUGE
100% RECYCLE TO PROCESS

SUBCATEGORY SUMMARY: BASIS 7/1/78 DOLLARS

Subcategory: Hot Coating-Other Metallic Coating
: Continuous and Batch
: Strip,Sheet, & Misc. Products

Model Size-TPD : 500
Oper. Days/Year: 260
Turns/Day : 2

Raw Waste Flows	(MGD)
Model Plant - no fume scrubbers:	0.3
Model Plant - with fume scrubbers:	0.6

Number of plants: 3 total, none currently with scrubbers
Total flow for strip, sheet, & misc. prod. with other metallic coating: 0.9 MGD
Total flow assuming scrubbers required: 1.8 MGD

odel Costs ($ x 10^{-3})	BAT Feed	BAT 1	BCT	BAT 2	BAT 3
lants with fume scrubbers					
Investment Cost	1240.0	219.0	354.0	380.0	2664.0
Annual Cost	242.0	57.7	82.0	87.1	551.4
$/ton of coated product(1)	1.86	0.444	0.631	0.670	4.24
lants without fume scrubbers					
Investment Costs	890.0	141.0	141.0	283.0	2419.0
Annual Cost	171.0	43.8	43.8	69.8	493.0
$/ton of coated product(1)	1.32	0.337	0.337	0.537	3.79

	astewater Parameters	Raw Waste		BAT Feed		BAT 1		BCT		BAT 2		BAT 3	
		w/fs	no fs	w/fs	no fs	w/fs	no fs	w/fs	no fs	w/fs	no fs	w/fs	no
	Flow, gal/ton	1200	600	1200	600	200	150	200	150	200	150	0	0
	pH (Units)	5-9	4-10	6-9	6-9	6-9	6-9	6-9	6-9	6-9	6-9	-	-
	oncentrations, mg/l												
	Suspended Solids	250	400	50		30		15	30	15		-	-
	Oil & Grease	50	60	15		5		5	5	5		-	-
	Hexavalent Chromium	0.02	0.02	0.02		0.02		0.02	0.02	0.02		-	-
	Dissolved Iron	20	30	1.0		0.2		0.2	0.2	0.2		-	-
	Tin	5	8	3		1.5		0.1	1.5	0.1		-	-
	Aluminum	25	30	5		2.5		0.1	2.5	0.1		-	-
15	Arsenic*	0.1	0.1	0.1		0.1		0.1	0.1	0.1		-	-
18	Cadmium*	2.0	4.0	0.5		0.1		0.1	0.1	0.1		-	-
19	Chromium, Total*	0.2	0.2	0.2		0.1		0.1	0.1	0.1		-	-
20	Copper*	0.5	1.0	0.3		0.1		0.1	0.1	0.1		-	-
22	Lead*	1.5	2.5	0.5		0.1		0.1	0.1	0.1		-	-
24	Nickel*	0.5	0.5	0.3		0.2		0.1	0.2	0.1		-	-
28	Zinc*	5.0	8.0	3.0		0.1		0.1	0.1	0.1		-	-

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1) BAT and BCT costs are incremental over BAT Feed costs.
Toxic pollutant found in all raw waste samples analyzed.

SUBCATEGORY SUMMARY: BASIS 7/1/78 DOLLARS

Subcategory: Hot Coating—Other Metallic Coating
: Continuous and Batch
: Wire,Wire Products & Fasteners

Model Size-TPD : 15
Oper. Days/Year: 260
Turns/Day : 2

Raw Waste Flows	(MGD)
Model Plant - no fume scrubbers:	0.0360
Model Plant - with fume scrubbers:	0.0585

Number of plants: 6 total, including 1 with fume scrubbers
Total flow for wire, wire products, and fasteners with other metallic coating: 0.2385 MGD
Total flow assuming scrubbers required: 0.351 MGD

Model Costs ($ x 10^{-3})	BAT Feed	BAT 1	BCT	BAT 2	BAT 3
Plants with fume scrubbers					
Investment Cost	413.0	51.0	0	131.0	1475.0
Annual Cost	76.0	11.4	0	25.9	271.6
$/ton of coated product(1)	19.49	2.92	0	6.64	69.64
Plants without fume scrubbers					
Investment Costs	341.0	17.0	17.0	93.0	1342.0
Annual Cost	62.5	5.3	5.3	19.1	246.3
$/ton of coated product(1)	16.03	1.36	1.36	4.90	63.15

Wastewater Parameters	Raw Waste		BAT Feed		BAT 1		BCT		BAT 2		BAT 3	
	w/fs	no fs	w/fs	no fs	w/fs	no fs	w/fs	no fs	w/fs	no fs	w/fs	no fs
Flow, gal/ton	3900	2400	3900	2400	750	600	3900	600	750	600	0	0
pH (Units)	5-9	5-9	6-9	6-9	6-9	6-9	6-9	6-9	6-9	6-9	-	-
Concentrations, mg/l												
Suspended Solids	100	150	50		30		50	30	15		-	-
Oil & Grease	25	40	15		5		15	5	5		-	-
Hexavalent Chromium	0.02	0.03	0.02		0.02		0.02	0.02	0.02		-	-
Dissolved Iron	12	25	1.0		0.5		1.0	0.5	0.3		-	-
Tin	3	5	3		1.5		3	1.5	0.1		-	-
Aluminum	12	25	5		2.5		5	2.5	0.1		-	-
115 Arsenic*	0.1	0.1	0.1		0.1		0.1	0.1	0.1		-	-
118 Cadmium*	1.0	2.0	0.5		0.1		0.5	0.1	0.1		-	-
119 Chromium, Total*	0.2	0.3	0.5		0.1		0.5	0.1	0.1		-	-
120 Copper*	0.3	0.5	0.3		0.1		0.3	0.1	0.1		-	-
122 Lead*	1.0	1.5	0.5		0.1		0.5	0.1	0.1		-	-
124 Nickel*	0.3	0.5	0.3		0.2		0.3	0.2	0.1		-	-
128 Zinc*	3.0	5.0	3.0		0.1		3	0.1	0.1		-	-

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(1) BAT and BCT costs are incremental over BAT Feed costs.
* Toxic pollutant found in all raw waste samples analyzed.

SUMMARY OF EFFLUENT LOADINGS (TONS/YEAR) AND TREATMENT COSTS
HOT COATING SUBCATEGORY

	Raw Waste Load	BAT Feed	BAT-1	BCT	BAT-2	BAT-3
A. **Galvanizing Operations:**						
Flow, MGD	31.80	31.80	6.56	6.56	6.56	0
TSS	2680.14	1723.88	213.37	106.69	106.69	-
Oil and Grease	1511.16	517.16	35.56	35.56	35.56	-
Hexavalent Chromium	42.35	0.70	0.14	0.14	0.14	-
Dissolved Iron	2043.93	34.48	1.42	1.42	1.42	-
Total Chromium	193.07	84.42	0.71	0.71	0.71	-
Zinc	2983.28	172.39	0.71	0.71	0.71	-
Other Toxic Metals	238.31	68.61	3.55	2.84	2.84	-
Toxic Organics	2.16	1.13	<0.16	<0.16	<0.07	-

OPTION COSTS
(MILLIONS OF DOLLARS)

Model Plant		BAT Feed		BAT-1		BCT		BAT-2		BAT-3	
		w/s	no s	w/s	no s	w/s	no s	w/s	no s	w/s	no s
Strip/Sheet/Misc. Prod. -	Capital	1.24	0.89	0.27	0.19	0.40	0.31	0.43	0.33	2.75	2.50
(800 TPD)	Annual	0.26	0.18	0.07	0.06	0.10	0.08	0.09	0.61	0.54	
Wire Products & Fasteners-	Capital	0.81	0.62	0.11	0.05	0.21	0.15	0.24	0.17	2.16	2.00
(100 TPD)	Annual	0.16	0.12	0.03	0.02	0.05	0.03	0.05	0.04	0.44	0.40
Galvanizing Subcategory											
Strip/Sheet/Misc. Products											
14 Plants w/scrubbers -	Capital	17.36		3.78		5.60		6.02		38.50	
	Annual	3.64		0.98		1.40		1.40		8.54	
20 Plants no scrubbers -	Capital	17.80		3.80		6.20		6.60		50.00	
	Annual	3.60		1.20		1.60		1.80		10.80	
Wire Products & Fasteners											
12 Plants w/scrubbers -	Capital	9.72		1.32		2.52		2.88		25.92	
	Annual	1.92		0.36		0.60		0.60		5.28	
17 Plants no scrubbers -	Capital	10.54		0.85		2.55		2.89		34.00	
	Annual	2.04		0.34		0.51		0.68		6.80	
Total Galvanizing Costs	- Capital	55.42		9.75		16.87		18.39		148.42	
63 Plants, 26 w/scrubbers	- Annual	11.20		2.88		4.11		4.48		31.42	

SUMMARY OF EFFLUENT LOADINGS AND TREATMENT COSTS
HOT COATING SUBCATEGORIES
PAGE 2

	Raw Waste Load	BAT Feed	BAT-1	BCT	BAT-2	BAT-3
B. Terne Coating Operations:						
Flow, MGD	1.75	1.75	0.33	0.66	0.33	0
TSS	106.85	94.97	10.68	27.30	5.34	-
Oil & Grease	54.62	28.49	1.78	8.31	1.78	-
Lead	1.19	0.95	0.04	0.26	0.04	-
Tin	11.87	9.50	1.07	2.73	0.04	-
Dissolved Iron	106.85	1.90	0.07	0.52	0.07	-
Other Toxic Metals	12.68	6.45	0.25	1.76	0.21	-
Toxic Organics	0.13	<0.06	<0.01	<0.02	<0.01	-

OPTION COSTS
(MILLIONS OF DOLLARS)

	BAT Feed	BAT-1	BCT	BAT-2	BAT-3
With Scrubbers - Capital	0.84	0.19	0.29	0.32	2.23
Annual	0.16	0.05	0.07	0.07	0.46
Without Scrubbers - Capital	0.61	0.12	0	0.23	2.02
Annual	0.12	0.04	0	0.06	0.41
Terne Coating Subcategory					
3 Plants with Scrubbers - Capital	2.52	0.57	0.87	0.96	6.69
Annual	0.48	0.15	0.21	0.21	1.38
2 Plants w/o Scrubbers - Capital	1.22	0.24	0	0.46	4.04
Annual	0.24	0.08	0	0.12	0.82
Total Costs - Capital	3.74	0.81	0.87	1.42	10.73
5 Plants, 3 w/Scrubbers - Annual	0.72	0.23	0.21	0.33	2.20

	Raw Waste Load	BAT Feed	BAT-1	BCT	BAT-2	BAT-3
C. **Other Metallic Coatings:**						
Flow, MGD	1.14	1.14	0.28	0.33	0.28	0
TSS	425.93	61.72	9.15	11.95	4.57	-
Oil & Grease	67.99	18.52	1.53	2.42	1.52	-
Dissolved Iron	34.91	1.23	0.08	0.14	0.07	-
Tin	8.97	3.70	0.46	0.63	0.03	-
Aluminum	34.91	6.17	0.76	1.05	0.03	-
Toxic Metals	18.21	6.13	0.24	0.56	0.21	-
Toxic Organics	<0.01	-	-	-	-	-

OPTIONS COSTS
(MILLIONS OF DOLLARS)

Model Plant	BAT Feed		BAT-1		BCT		BAT-2		BAT-3	
	w/s	no s	w/s	no s	w/s	no s	w/s	no s	w/s	no s
Strips/Sheet/Misc. Prod. - Capital	1.24	0.89	0.22	0.14	0.35	0.14	0.38	0.28	2.66	2.42
Annual	0.24	0.17	0.06	0.04	0.08	0.04	0.09	0.07	0.55	0.49
Wire Products & Fasteners - Capital	0.41	0.34	0.05	0.02	0	0.02	0.13	0.09	1.48	1.34
Annual	0.08	0.06	0.01	0.01	0	0.01	0.03	0.02	0.27	0.25

	BAT Feed	BAT-1	BCT	BAT-2	BAT-3
Other Metallic Coatings Subcategory:					
Strip/Sheet/Misc. Prod.					
0 Plants currently have scrubbers	-	-	-	-	-
3 Plants w/o scrubbers - Capital	2.67	0.42	0.42	0.84	7.26
Annual	0.51	0.12	0.12	0.21	1.47
Wire Products & Fasteners					
1 Plant with scrubbers - Capital	0.41	0.05	0	0.13	1.48
Annual	0.08	0.01	0	0.03	0.27
5 Plants w/o scrubbers - Capital	1.70	0.10	0.10	0.45	6.70
Annual	0.30	0.05	0.05	0.10	1.25
Total Other Metal Coatings:					
9 Plants, 1 with scrubbers - Capital	4.78	0.57	0.52	1.42	15.44
Annual	0.89	0.18	0.17	0.34	2.99
Overall Total - All Hot Coatings:					
77 Plants, 30 with scrubbers - Capital	63.94	11.13	18.26	21.23	174.59
- Annual	12.81	3.29	4.49	5.15	36.61

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